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ILLINOIS WATERWAY REPORT

WITH

PLANS AND ESTIMATES OF COST FOR A
WATERWAY FROM LOCKPORT, ILLINOIS
TO UTICA, ILLINOIS, BY WAY OF
THE DESPLAINES AND ILLI-
NOIS RIVERS.

BY THE

INTERNAL IMPROVEMENT COMMISSION
OF ILLINOIS.

1909.



SPRINGFIELD, ILL.,
ILLINOIS STATE JOURNAL CO., STATE PRINTERS
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for maps see

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LETTER OF TRANSMITTAL.

CHICAGO, March 1, 1909.

Hon. Chas. S. Deneen, Governor of the State of Illinois:

SIR—The Forty-fifth General Assembly enacted the following legislation:

“AN ACT to amend sections one and two of an Act entitled, ‘An Act to provide for the appointment of an internal improvement commission and to make an appropriation therefor,’ approved May 16, 1905, in force July 1, 1905.”

SECTION 1. *Be it enacted by the People of the State of Illinois, represented in the General Assembly:* That sections one and two of an Act entitled, “An Act to provide for the appointment of an internal improvement commission, and to make an appropriation therefor,” approved May 16, 1905, in force July 1, 1905, be and the same is hereby amended so as to read as follows:

1. There shall be appointed by the Governor a commission to be known as the Internal Improvement Commission of Illinois, to be composed of three persons of high practical business qualifications, two of whom at least shall reside in the counties contiguous to a navigable river in the State. At the expiration of two years from the date of appointment of said commission, successors to those first appointed shall be appointed by the Governor, whose terms of office shall be four years.

2. The duties of this commission shall be to investigate the various problems associated with a projected deep waterway from Lake Michigan to the Gulf of Mexico, and the reclamation of lands subject to overflow or inundation, the construction of practical and substantial levees, the ascertaining of the acreage of lands now subject to inundations from rivers, the increase from benefits to be derived from this proposed deep waterway and reclamation of lands subject to overflow or inundation and such other statistics and data as will intelligently enable the next General Assembly to properly formulate and devise ways and means whereby legislative enactment may be had to carry out and put into effect the benefits to be derived by the deep waterway from Lake Michigan to the Gulf of Mexico and reclamation of lands subject to inundation in Illinois. The results of these investigations and studies, together with all obtainable data and statistics, to be embodied in a report of all its workings to the next General Assembly. Such commission shall receive no compensation for its services other than the necessary and legitimate expenses incurred by it in the discharge of its official business.

APPROVED December 24, 1907.

“AN ACT making an appropriation to the Internal Improvement Commission of Illinois, to be used in defraying the necessary expenses of said commission in reporting upon a navigable waterway between East St. Louis and Cairo, approved February 21, 1908.”

SECTION 1. *Be it enacted by the People of the State of Illinois, represented in the General Assembly:* That there is hereby appropriated to the Internal Improvement Commission of Illinois the sum of ten thousand dollars (\$10,000.00) to be expended in the procurement and preparation of information needed by said commission to enable it to report to the next session of this General Assembly upon the practicability, character, and probable cost of a deep waterway between East St. Louis and Cairo, Illinois.

Sec. 2. The Auditor of Public Accounts is hereby authorized and directed to draw his warrant from time to time for the moneys herein appropriated, upon proper vouchers, certified by said commission and approved by the Governor."

"AN ACT making an appropriation to the Internal Improvement Commission of Illinois, for the purpose of repairing and strengthening the levee at Shawneetown, Illinois, approved May 17, 1907.

SECTION 1. *Be it enacted by the People of the State of Illinois, represented in the General Assembly:* That there is hereby appropriated to the Internal Improvement Commission of Illinois, the sum of seventeen thousand dollars (\$17,000.00) for use in repairing and strengthening the levee at Shawneetown, Illinois, so as to protect said city from floods and overflows of the Ohio and Wabash rivers.

Sec. 2. The Auditor of Public Accounts is hereby authorized and directed to draw his warrant from time to time upon the State Treasurer for the moneys herein appropriated upon proper vouchers, certified by the said commission and approved by the Governor."

On February 20, 1908, your Excellency reappointed as commissioners of the Internal Improvement Commission of Illinois, Mr. Isham Randolph of Chicago, Mr. H. W. Johnson of Ottawa, and Mr. H. M. Schmoldt of Beardstown. At a meeting under date of February 25, 1907, Mr. Randolph was made chairman. At meeting held March 24, 1908, Mr. Lyman E. Cooley was appointed consulting engineer and Mr. Robert Isham Randolph was appointed secretary.

The repairs to the Shawneetown levee were successfully completed on August 21, 1908, and the mayor and levee committee accepted the work and expressed satisfaction with methods and results. A statement of disbursements of this account has been filed with the State Auditor and the secretary's report is submitted herewith in the appendix.

The commission has collected maps and data on the regimen and physical characteristics of the Mississippi river between St. Louis and Cairo, but will defer its report on this division of the Lakes-to-the-Gulf waterway until such time as the more exhaustive investigation of the Mississippi River Commission makes complete data available. The funds available for this work are not sufficient for original surveys and investigation in a problem of such magnitude, and in view of the fact that the Mississippi River Commission is making a study of this division with ample funds your commission feels justified in withholding judgment until such time as the results of these studies are available.

In coöperation with the United States Geological Survey, the Department of Agriculture and the State Geological Survey, the commission has been collecting data for the proper study of the problem of conservation of the water resources of the State. Under this scheme of coöperation these three agencies are acquiring data valuable to each of them and for which they each pay a part of the cost. This commission has assumed the expense of gauging streams in Illinois during the past year and will have this data, together with the completed topographical maps of the several stream basins, for use in determining the proper treatment for regulation and control of the streams and the conservation of water supply in the several districts. Fourteen gauging stations are being maintained at the present time; five on the Kaskaskia and tributaries; five on the Sangamon river and tributaries;

two on the Big Muddy and tributaries, and two on the Little Wabash and tributaries. Daily readings are taken on these gauges and flow measurements are taken from time to time, seventy measurements having been made during the past year. The data obtained during the past year are of great value as they cover a period of exceptionally low water, but the collection of data should be continued over a series of years to be of most value. The question of water supply both for domestic and commercial uses is a very serious problem in Southern Illinois and as the population increases it will become more serious.

The following table shows the location and record of the stations maintained by the commission:

GAUGING STATIONS IN THE STATE OF ILLINOIS.

Maintained by the Internal Improvement Commission.

Stream.	Station.	Date established.	Number of measurements.	Length of Record.
Sangamon	Monticello	Feb. 4, 1908	7	Feb. 4, 1908, to Jan. 1, 1909..
Sangamon	Riverton	Feb. 13, 1908	5	Feb. 13, 1908, to Jan. 1, 1909..
Sangamon	Chandlerville	Feb. 9, 1908	2	Feb. 9, 1908, to Jan. 1, 1909..
South Fk. Sangamon	Taylorville	Feb. 11, 1908	5	Feb. 11, 1908, to Jan. 1, 1909..
Salt Creek	Kenney	Feb. 14, 1908	4	Feb. 14, 1908, to Jan. 1, 1909..
Kaskaskia	Arcola	Apr. 11, 1908	2	Apr. 11, 1908, to Jan. 1, 1909..
Kaskaskia	Shelbyville	Feb. 25, 1908	6	Feb. 25, 1908, to Jan. 1, 1909..
Kaskaskia	Vandalia	Feb. 26, 1908	10	Feb. 26, 1908, to Jan. 1, 1909..
Kaskaskia	Carlyle	Mar. 2, 1908	8	Mar. 2, 1908, to Jan. 1, 1909..
Silver Creek	Lebanon	Mar. 3, 1908	8	Mar. 21, 1908, to Jan. 1, 1909..
Big Muddy	Cambon	June 16, 1908	3	June 16, 1908, to Jan. 1, 1909..
Beaucoup Creek	Pinckneyville	June 17, 1908	4	June 17, 1908, to Jan. 1, 1909..
Little Wabash	Golden Gate	Aug. 17, 1908	3	Aug. 17, 1908, to Jan. 1, 1909..
Skillet Fork	Wayne City	Aug. 16, 1908	3	Aug. 16, 1908, to Jan. 1, 1909..
Total .....	.....	.....	70	

The topographic work of this Illinois coöperation, begun in 1907, was continued through the season of 1908, resulting in complete surveys of the Kaskaskia river from the wagon bridge, one and one-half miles southeast of Cowden, to its outlet near Chester; Shoal creek from the wagon bridge six miles west and one mile south of Greenville, to its outlet into the Kaskaskia river, and the Big Muddy river from near Mulkeytown to the Mississippi. The distance along the surveyed portion of the Kaskaskia river, by direct line through the bottoms, is 118 miles; Shoal creek twenty-nine miles and the Big Muddy fifty miles.

In addition to these completed maps, a primary level line has been run from Beardstown along the Sangamon river to Petersburg, and from Springfield to Decatur. From Decatur, the line continues north along the Illinois Central Railroad to Clinton and thence west along Salt river to the Sangamon and south to Petersburg. This line of levels will serve as vertical control for the work along the Sangamon and Salt rivers.

The total area surveyed is 496 square miles, of which 348 are included in the Kaskaskia river survey, forty-eight in the Shoal creek survey and 100 in the Big Muddy. Of the 348 square miles along the

Kaskaskia river, there are 160 determined elevations per square mile, which makes a total of 2,480 miles of traverse and 24,800 elevations, which are distributed along these streams as follows:

	Miles Traverse.	Elevations.
Kaskaskia River	1,740	17,400
Shoal Creek	240	2,400
Big Muddy River	500	5,000
Totals	2,480	24,800

In addition to the ground elevations, levels have also been taken of a sufficient number of high water marks to make it possible to show upon the completed maps, the extent of the flooded section. With this information plotted on the maps, it will be possible to see at a glance the extent of the flood along the entire length of the stream. Elevations have also been determined of the approximate low water, but because of the quick changes in the level of the water surface, and the lack of stream gauges, these elevations may vary as much as three feet from a given stage. However, they should be useful in giving a fairly accurate idea of the fall between different points along the stream.

In their completed form, the maps are divided into sections or sheets, which are given the name of the largest town, or if there be no town, of the best known feature which it contains. The size of the sheets are not uniform, but necessarily vary in order to fit the changing course of the stream. The approximate size will be, to the scale of the map 9 x 11 miles.

The scale is 1:24000, or one inch 2,000 feet, and the contour interval five feet. Following is a list of the completed sheets:

KASKASKIA RIVER.	SHOAL CREEK.	BIG MUDDY RIVER.
Lorton Bridge.	Breese.	There will be 5 or 6 sheets along this stream. They were surveyed under the direction of Mr. W. J. Lloyd of the U. S. G. S., and are being put into map form by him.
Vandalia.	Frogtown.	
Soper Lake.		
Carlyle.		
Santa Fé.		
Queen's Lake.		
Fayetteville.		
Round Pond.		
Evansville.		

The work as previously planned for 1908 included the Kaskaskia river, Big Muddy, Shoal creek and a small section of the Little Wabash south of Carmi, and the level work on the Sangamon. All of this, with the exception of the Little Wabash, was completed as planned.

The commission has made a personal inspection and reconnaissance of the Kaskaskia, Big Muddy, Mississippi, Ohio, Wabash and Little Wabash rivers, studying from personal observation the possibilities of these streams for commercial development, their regulation and control, and the reclamation and preservation of contiguous bottom lands from overflow.

By your instructions the commission has promoted the projected waterway on all proper occasions. The secretary has conducted an extended correspondence with waterway organizations, prepared sundry addresses and contributed waterway articles to several publications.

The commission attended the Lakes-to-the-Gulf Waterways Association Convention in Chicago on October 7, 8 and 9; the National Rivers and Harbors Congress in Washington, December 9, 10 and 11; and was represented at the Gulf Coast Inland Waterways Association Convention in Mobile, Ala., May 7th, the Mississippi to Atlantic Inland Waterways Association in Columbus, Ga., on November 9 and 10, the Mobile Basin and Tennessee River Association Convention in Mobile on November 23 and 24, and the Inter-State Inland Waterways Association Convention in New Orleans on December 4 and 5.

In order to enlighten the voters upon the proposition to amend the Constitution and issue twenty million dollars in bonds for the construction of a waterway from Lockport to Utica, the commission prepared a synopsis of its plan for this development and distributed 510,000 copies of the same throughout the State. This circular was the only authoritative information from an authorized agency of the State upon the provisions of this act, and the possibilities of this development.

The report herewith is the result of the studies and estimates of your commission and is its final recommendation for a plan of development. Features discussed tentatively in our previous report, such as the dimensions of locks, treatment of channel, location of power houses and estimates of cost, are here crystallized and presented as the findings of your commission.

We reprint so much of the original report as is consistent with the conclusions we have arrived at after another period of study of the problems committed to us.

For the history and physiography therein contained we are pleased to acknowledge our indebtedness to Mr. Lyman E. Cooley.

Very respectfully submitted,

THE INTERNAL IMPROVEMENT COMMISSION OF ILLINOIS,

ISHAM RANDOLPH, *Chairman*,

H. M. SCHMOLDT,

H. W. JOHNSON.

ROBERT ISHAM RANDOLPH, *Secretary*.

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THE LAKES AND GULF WATERWAY.

Part I. Preliminary Consideration.

1. INTRODUCTION—PHYSICAL RELATIONS.

The Chicago divide is the site of the ancient outlet of the Great Lakes. Three distinctive shore lines about the head of Lake Michigan record successive stages of the receding waters as the eastern outlet developed—the forty foot beach (above standard low water), known as the West Ridge, from Evanston to Rose Hill; the twenty-four foot beach, which is the site of Northwestern University and extends to the north side of Chicago; and the fourteen foot beach, developed at Englewood—and changes seem to be still in progress in the Port Huron outlet, which indicate an ultimate level somewhat lower than the present state. Professor G. K. Gilbert, United States Geologist, under the title, "Earth Movement in the Great Lakes Region," (see Report of the U. S. Geological Survey, vol. XVIII. 1896-7.) predicts that the Chicago outlet will be restored in about twenty-five hundred years.

The Chicago Divide is about midway of the continental valley, extending 3,300 miles by the water trail from the Gulf of Mexico to the Gulf of St. Lawrence. The virtual summit, the rock floor in the Desplaines valley above Lemont, is at an elevation of 587 feet above mean sea level, or less than the altitude of the Washington Monument in the District of Columbia. More than 900 miles away by the water route the rock floor of the Niagara river, where it leaves Lake Erie, is only thirty feet lower, or at about the level of the bottom of the Chicago Drainage Canal. To the northeast, the outlet developed in lakes and rock-bound declivities to the St. Lawrence estuary. From the south, alluvial grades developed northward to Utica, leaving some eighty miles of half completed rock-bound valley to the old shore line near Lyons. Some ten miles of additional rock erosion above Joliet would have maintained the southern outlet.

In the ice cap period, an estuary of the Gulf of Mexico extended north to the vicinity of Cairo, and glacial lobes converged on the low lying region represented by Illinois and the adjacent margins of bordering states. The topographic relief was built up as far south as parallel $37\frac{1}{2}$ degrees (Grand Tower to Shawneetown), and the southern estuary filled in as the delta or alluvial region of over 30,000 square miles between Cairo and the Gulf. Water passes were carved across the northern highlands and between the lake region and the Mississippi Valley, from

all of which the flow gravitated toward the region of Illinois. The Chicago outlet is the lowest, practically, at the present Michigan-Huron level, and from 180 to 440 feet lower than all others.

The pass from the Winnipeg basin and the Canadian northwest, the Red-Minnesota Divide, is at an elevation of 960 feet; the St. Croix pass from the head of Lake Superior, 1,020 feet; the Fox-Wisconsin at Portage, Wisconsin, 790 feet; the Maumee-Wabash near Fort Wayne, Indiana, at 760 feet; the Grand-Mahoning near Warren, Ohio, at 900 feet, the site of the proposed Lake Erie and Ohio river ship canal; and there are four intermediate passes in Ohio at 910-960 feet, two of which are utilized by state canals. The Chicago outlet by way of the Illinois river crosses the State of Illinois, and the routes from all the other water passes come to her borders by way of the Upper Mississippi, the Wabash and the Ohio, and ultimately converge at Cairo. The Missouri river coming remotely from the Rocky Mountains; the Cumberland and the Tennessee impinge on her shores. Illinois is the natural focus of a continental waterway system, and should benefit most largely by a general waterway policy.

That the Illinois region is low lying is to be inferred from the foregoing. As a matter of fact, the State of Illinois is the lowest in elevation of any of the interior states, being 100 feet lower than Indiana, 250 feet lower than Ohio, 300 feet lower than Michigan, 450 feet lower than Wisconsin, 600 feet lower than Minnesota, 500 feet lower than Iowa and 200 feet lower than Missouri—lower even than Kentucky, Tennessee, or Arkansas. (See Report U. S. Geological Survey, Vol. XIII. Pt. II, p. 289, 1893.) The actual average elevation of the State, as deduced by Professor Frank Leverett (Water Resources of Illinois, Report U. S. Geological Survey Vol. XVII, Pt. II, 1896) is 632 feet, or fifty-three feet above the Michigan Huron Lake. Such a condition carries a moderate climate well north, making navigation possible in ordinary winters up to parallel 42 degrees at Chicago and Clinton.

The State of Illinois is also remarkably uniform in elevation. Professor Leverett's table shows that in a total area of 56,650 square miles, only 125 miles lie above an elevation of 1,000 feet, 4,990 miles between 1,000 and 800 feet, and 1,925 miles below 400 feet; while 31,185 miles, or 55 per cent, lie between elevations 800 and 600 feet; and 18,425 miles, or 32½ per cent, between elevations 600 and 400 feet—in other words, more than half the State lies within a range of 200 feet and seven-eighths within a limit of 400 feet. The streams are well distributed and the headwater summits, by which the several basins may be connected, are generally low. The resources of the State are great and very uniformly spread out, and all the conditions invite a dense population. When the need shall appear, as it has in foreign lands, no other state is better adapted to the development of a domestic waterway system.

2. THE DISCOVERY.

In 1673, Joliet and Marquette, going by way of the Fox-Wisconsin route from Green Bay, discovered the Mississippi river, and floated down the same to the mouth of the Arkansas river. On their return

they were persuaded by the Illinois Indians to take the Illinois river, and were the first white men to cross the Chicago Divide, in September, 1673.

Resting at the head of Lake Michigan from his hazardous voyage on the Great Lakes, Marquette, under date of August 1, 1674, first proposed a canal across the Chicago Divide, in a letter to his friend, Father Dablon, as follows:

"A very important advantage, and one which some, perhaps, will find it hard to credit, is that we could easily go to Florida in boats, and by a very good navigation. There would be but one canal to make—by cutting one-half of a league of prairie—to pass from the lake of Illinois (Lake Michigan) into the St. Louis river (Desplaines river.) The route to be taken is this: The bark should be built on Lake Erie, which is near Lake Ontario. It could easily pass from Lake Erie to Lake Huron, from which it would enter the lake of Illinois. At the extremity of this lake would be the cut or canal of which I have spoken, to have a passage to the St. Louis river, which empties into the Mississippi. The bark, having entered this river, could easily sail to the Gulf of Mexico."

Marquette returned to Chicago late in 1674, and wintered "two leagues" from the lake, adjacent to the west fork of the south branch of the Chicago river, near Robey street. On March 29, 1675, he was driven from his cabin by flood waters, due to the spring breakup of the Desplaines river and ice gorges. He secured his effects in trees and took refuge on a "hillock." On March 31, he crossed the divide in his canoes and proceeded to the Illinois country, passing the site of Utica, on April 8. Sickness soon compelled Marquette to abandon his mission, and he died on the east shore of Lake Michigan, near the mouth of St. Joseph river, on his return journey. The hillock or mound on which Marquette took a refuge stood adjacent to the west fork at Robey street, and was about 350 feet long by 100 feet wide and sixteen feet above lake level, and was not entirely removed until 1880.

LaSalle was fired by the exploits of Joliet and Marquette. He had already explored down the Ohio river as far as Louisville, and planned an extended scheme of exploration and commercial venture. In 1679 he built the Griffin on the shores of the Niagara river, and with her made the trip to Green Bay, the first vessel to sail the upper lakes. He selected the mouth of the St. Joe river apparently as a suitable harbor and there established Fort Miami. He proceeded up the St. Joseph river and crossed over to the Kankakee marshes near South Bend, Indiana, and thence down the Kankakee river and the Illinois to the Illinois villages, where he arrived Jan. 1, 1680. He established Fort Creve Coeur, on the east side of Lake Peoria and northeast from the present city of Peoria, and started to build a suitable vessel with which to descend the Illinois and Mississippi. His resources and organization were inadequate, and, after despatching Father Hennepin to explore the Upper Mississippi, on March 2, he set out on his return to Fort Miami, going by way of the Desplaines river to Joliet, thence overland to Lake Michigan, near the mouth of the Calumet.

LaSalle made a new start in 1681, and his party rendezvoused at "Checaugou" on Jan. 4, 1682, and proceeded over the ice on sleighs to Lake Peoria, where he found open water, and at once launched his boats

and proceeded southward by the Illinois and Mississippi rivers, reaching the margin of the Gulf of Mexico on April 9. He returned to the Illinois country and established Fort St. Louis at Starved Rock, opposite Utica, in December, 1682, and, owing to the removal of Governor Frontenac, remained in the Illinois country until the autumn of 1683, when he returned to France, leaving Tonti in command. Fort St. Louis was besieged by Iroquois Indians for six days in March, 1684.

LaSalle fitted out a new expedition to reach the interior by way of the Mississippi river from the Gulf of Mexico. He missed the mouth of the river and landed at Matagorda Bay, Texas, Jan. 12, 1687. After establishing a fort and making local explorations, he set out overland for the Mississippi river on his way to Canada, but was assassinated by members of his party near Trinity river, Texas, March 19, 1687. On Feb. 13, 1686, Tonti left Fort St. Louis in search of LaSalle, and on his return built a fort near the mouth of the Arkansas river, where fugitives from LaSalle's party arrived on Sept. 14, 1687. They reached Fort St. Louis and remained there during the winter and returned to France by way of the Chicago portage in 1688.

A fort was built by Durantaye at "Checaugou" in 1685, but the exact site and its name are unknown.

The French established a chain of forts from the lakes to the gulf, and protected from their hereditary enemies, east and west, the Illinois Indians increased greatly in numbers and prospered. In 1769 Pontiac, the great Indian leader, was assassinated by an Illinois Indian at Cahokia, opposite St. Louis, an act which was approved by the Illinois tribes. The northern Indians, in revenge, practically exterminated the Illinois tribes, the war culminating in the massacre at Starved Rock in 1770.

The actual "divide," or water parting, at the time of the discovery and up to 1852, was within the present limits of the city of Chicago, near Kedzie avenue. The original land surveys of 1821 show an extended marsh, fed through a slough from the Desplaines river at the range line north of Summit. The two arms of this marsh overflowed in high water near Kedzie avenue, into the West Fork near the Bridewell and into the South Fork near Brighton and west from the stock yards. From the junction of these two forks, the South Branch and the main river out to the lake sand bar, had a natural depth of over twelve feet and a capacity several times that of the north branch, though the territory normally drained was comparatively limited. The inference is plain, that the south branch with its two forks was the proper outlet for the flood waters of the Desplaines river and was maintained thereby.

Topographical surveys identify an old river bed in the Mud Lake region, and along the present line of the Ogden-Wentworth ditch, which was probably at one time the bed of the Desplaines river when it flowed to Lake Michigan, much like the Calumet within the historic period. What occasioned the diversion down the present course of the Desplaines river is a matter of speculation—it may have been due to silt deposits initiated by a beaver dam near Kedzie avenue. The present course bears every evidence of being very recent—the silt deposits over

the rock are very limited and the river bed occupies a mere surface depression, with little or no rock erosion.

The original portage was then from the west fork near the Bridewell to Mud Lake, beyond Kedzie avenue; thence navigation was continued by a slough to the Desplaines river and through the "twelve mile level" to the rock above Lemont, a water stretch of some eighteen miles, and having a low water level only eight feet above low lake level and less than four feet above high lake. Such conditions naturally made the Chicago divide the most famous portage between the lakes and the Mississippi river.

From the end of the "twelve mile level" to Lake Joliet was seventeen miles—a mere surface stream over the rock bed—with a steep declivity over the lower half of the distance descending to a level 76.5 feet below Lake Michigan. Eight out of thirteen miles between the head of Lake Joliet and the head of the Illinois river at the Junction with the Kankakee, is occupied by two deep pools, Lake Joliet and Lake DuPage, with intermediate declivities of seventeen feet. The flow from the Kankakee river itself was originally well maintained from the great marsh expanses at head waters.

Under date of April 4, 1819, Messrs. R. Graham and Joseph Phillips report from Kankakee as follows:

"The route by Chicago as followed by the French since the discovery of the Illinois, presents at one season of the year an uninterrupted boat communication of six to eight tons burden between the Mississippi and the Michigan lake; at another season a portage of two miles; at another, a portage of seven miles from the bend of the Plein (Desplaines) to the arm of the lake. And at another, a portage of fifty miles from the mouth of the Plein to the lake, over which there is a well beaten wagon road. Boats and their loads are hauled by oxen and vehicles kept for that purpose by the French settlers at Chicago."

In 1849 the divide was overflowed at the spring breakup, much as in 1675, when Marquette was driven from his cabin, with ice gorges and great destruction of shipping and bridges in the Chicago river.

The southern arm of Mud Lake was intercepted by the Illinois and Michigan canal (opened in 1848) and drained to the south fork by the State ditch at Brighton. In 1852 the Cook County Drainage Commissioners cut a ditch four feet wide and three feet deep into Mud Lake from the West Fork, and this had enlarged to great proportions by 1856. The same commission also cut a similar ditch from Mud Lake to the Desplaines river, but this silted up. In 1871 private parties opened up what has since been known as the Ogden-Wentworth ditch, but this brought so much silt to the Chicago river and to the canal, then just deepened, that it was regarded as a nuisance. A dam was built at the range line near Summit, in 1874, its height being fixed by agreement, at the level of the divide that had formed at the margin of the Desplaines river, or at 11.73 feet above Chicago datum (low water of 1847) and 3.7 feet above the summer level of the "twelve mile level" and the rock floor at Lemont, thirteen miles below.

Below the mouth of the Kankakee river the voyageur had ample water in the open season to the Indian town located on the water line uplift at Utica, where there are copious springs from the overlying St. Peter's

sandstone. Opposite was Fort St. Louis, later Starved Rock, at the immediate head of the alluvial valley and the head of the present pool created by the dam at Henry. The fall at low water was about fifty-three feet in forty-two miles, largely concentrated in rock-bound declivities—four feet in one mile below the Kankakee; eighteen feet in two miles below Kickapoo reef, opposite Marseilles, and ten feet in two and a half miles above Fort St. Louis, and a deep pool covered more than twelve miles above Kickapoo reef.

From Fort St. Louis (Utica) was an easy current to the Mississippi, a descent at low water of only twenty-eight feet in 229 miles. This gentle declivity expressed the great volume of the old outlet, and a remnant of the ancient stream bed survives in Lake Peoria, much contracted in historic times. The detritus from tributaries has determined the course and shaped the bed of the modern stream, shrinking it to the requirements of the present drainage basin, an adjustment in grades and prism that will take a geologic age to complete. In the report of 1867, upon the survey and project "for a system of navigation * * * adapted to military, naval and commercial purposes," General James H. Wilson describes the bottom lands as follows:

"Intersected by lagoons and swamps, covered with a dense growth of willow, these bottoms seem impenetrable. Such is the desolate appearance of the silent swamps and lagoons, that Captain Howard Stansbury, in a report of a survey made in 1838, expresses the opinion that they must 'ever remain uninhabited.' This may be true, until a denser population gives a sufficient value to the land to justify a reclamation by levees. Already cultivation has begun to enroach on the bottoms."

Stansbury saw the situation substantially as it was seen by the discoverers, and little change had occurred in Wilson's day.

3. EARLY HISTORY.

The ordinance of Virginia (July 13, 1787) accepting the cession of the northwest territory (northwest of Ohio river) provided as follows:

"The navigable waters leading into the Mississippi and the St. Lawrence, and the carrying places between the same, shall be common highways, and forever free, as well to the inhabitants of the said territory as to the citizens of the United States, and those of any other state that may be admitted into the Confederacy, without any tax, impost, or duty therefor."

The Indian Treaty of August 3, 1795, cedes territory as follows:

"One piece of land six miles square at mouth of Chicago river * * * * where a fort formerly stood; one piece twelve miles square at or near the mouth of the Illinois; one piece six miles square at the Old Peorian fort and village, near south end of the Illinois lake (Lake Peoria) on the said Illinois river."

In his celebrated report on Means of Internal Communication, in 1808, Albert Gallatin gave a prominent place to the project for a ship canal across the Chicago portage.

In 1811 the Illinois waterway was reported to Congress in a bill along with the proposed Erie and other canals.

From 1808 to 1825 the "proposed ship canal" was repeatedly advocated by Clinton and Morris as an extension of the Erie canal to the Mississippi river.

President Madison, in his message to Congress in 1814, invites attention to the importance of a ship canal between Lake Michigan and the Illinois river.

On August 24, 1816, a treaty was made with the Ottawa, Chippewa and Pottawatomie Indians, by which they relinquished all territorial claims south of the parallel touching the south end of Lake Michigan, and ceded the territory within ten miles of the water route, or what is known as the Indian boundary line extending from the Fox river to Lake Michigan on the north, and from Lake Michigan to the Kankakee river on the south.

In 1816 Major Long, who had been sent to rebuild Fort Dearborn, reported to George Graham, Secretary of War, on "The Practicability of a Ship Canal." He examined the Illinois, Kankakee and Desplaines rivers, and among other things says:

"The water course which is already open between the river Desplaines and the Chicago river, needs but little more excavation to render it sufficiently capacious for all the purposes of a canal."

At the instance of Judge Nathaniel Pope, territorial delegate to Congress, the bill for the admission of Illinois as a State in 1818 fixed the northern boundary at parallel 42 degrees, 30 minutes, in place of the territorial boundary established by the ordinance of Virginia at the parallel touching the south end of Lake Michigan, in order that the new State might have a port on Lake Michigan, and that the construction of the waterway between Lake Michigan and the Mississippi river should not be prejudiced.

The land surveys of 1821 meandered the Desplaines river up to the highway in the village of Lyons, or to the seven mile portage road from the Chicago river.

In 1822 the United States granted a right of way through the public lands, and in 1827 made a grant of land—alternate sections five miles on either side and amounting to 284,000 acres—in aid of a waterway from Lake Michigan to the navigable waters of the Illinois river. Supplemental legislation was passed in 1833, 1842 and 1854. The State of Illinois took action in 1823, authorized canal construction in 1829 and began work in 1836. The State submitted plans in 1825, a survey was made by the United States in 1830, and further surveys by the State in 1833.

The work was prosecuted under financial vicissitudes, and finally opened in 1848, with the plan modified to a summit level eight feet above Lake Michigan (low water of 1847, Chicago datum) with a feeder through Sag Valley from the Calumet river, supplemented by lift wheels at Bridgeport, when the water supply was deficient. These wheels were operated at time to cleanse the Chicago river, and in 1866-71 the city of Chicago cut down the summit level according to the original plans, and the waters of Lake Michigan flowed by gravity to the Mississippi. The expenditure for this work was refunded by the State after the great fire of October, 1871. In 1881 the Legislature, by joint resolution, required the city of Chicago to erect and maintain pumping works at the canal entrance at Bridgeport, to increase the flow for sanitary reasons, and these were put in operation in 1884 and have since continued.

The canal was 97.24 miles long, descending to 146.6 feet below lake level at LaSalle (low water in the Illinois), six feet deep, sixty feet wide at surface and thirty-six feet at bottom in earth, and forty-eight feet wide in rock, with locks 110 feet long, eighteen feet wide and six feet deep on miter sills.

There were differences of opinion as to the treatment and scope of the enterprise. The canalization of the river below Joliet, in lieu of the canal, was strongly advocated. As late as 1838 General Dearborn wrote from Chicago that the canal is to be of "such enlarged dimensions as to permit the passage of large vessels, being ten feet deep," or all that could then be carried by lake across the St. Clair flats. Clinton is stated to have visited Chicago in the interests of the "ship canal" in 1826 (unverified statement of the late ex-Senator Doolittle) and to have made a speech in Steuben county after his return to New York in which he said: "I stood on the banks of a little reedy stream called the Checagou river, where in forty years will be a great city, not less than 200,000 inhabitants." Notwithstanding its limited capacity, the canal served its day so well that in 1885 Canal Commissioner Brainerd estimated that it had saved the people of the State within reach of its service not less than \$180,000,000 in freight charges.

The canal failed to develop its full utility, as long continued low water periods in the lower Illinois river gave bar depths as little as one and a half to four feet. The United States did a limited amount of dredging in 1852 (under Joe Johnson, later famous in the Confederate army) and the good effects were apparent fifteen years later. In 1858 John B. Preston projected a steamboat waterway—same dimensions recommended by General Wilson in 1867—and this, in conjunction with an enlarged Erie canal, was urged in Congress in 1862 as a war measure. In 1866 Congress ordered surveys and a project "for a system of navigation, by way of the Illinois river, between the Mississippi and Lake Michigan, adapted to military, naval and commercial purposes." General James H. Wilson made a preliminary report in 1867, and in conjunction with William Gooding, engineer of the Illinois and Michigan canal, a final report in 1868. The project recommended was a canal, 160 feet wide and six feet deep (eight feet at mean level) across the Chicago divide to Lockport, with a grade of one-tenth foot per mile; the same dimensions continued to Lake Joliet; the improvement of the river by dams and locks to Utica, with a depth of seven feet, and also the improvement of the lower river by locks and dams to the same depths—all locks to be 350 feet long and seventy-five feet wide, with seven feet depth on the miter sills.

It was considered that an addition of 4,555 second feet to the extreme low water volume (633 second-feet at LaSalle) would produce the required depth between Utica and the mouth of the river "by the aid of one, or at the most, two dams, together with a small amount of dredging." The plan (which seems to have been that of Preston) was considered as beyond "any reasonable cost." This conclusion was based on an ill-considered design for the supply channel across the Chicago divide. Assistants Robert E. McGrath and Colonel H. A. Ulffers vigorously protested against the lock and dam project for the lower Illinois,

and up to 1880 all appropriations by the United States were expended in dredging, except \$62,359.80 applied to the foundation of the Copperas Creek lock.

The State of Illinois undertook the improvement from the surplus canal earnings, and in 1871 opened the lock and dam at Henry, and in 1877, the lock and dam at Copperas Creek.

In special reports, 1878-80, Captain G. J. Lydecker considers locks and dams somewhat cheaper than open channel improvement, and the United States opened the work at LaGrange in 1889, at Kampsville in 1893. He estimated it to be feasible to obtain six feet in an open channel, with the low water volume below Copperas Creek, measured in 1879, at 1,566 second-feet (261 furnished from Lake Michigan by the canal.)

In 1874, Mr. F. C. Doran, under Colonel J. N. Macomb, made a survey from Chicago to Hennepin, as part of the northern transportation route from the upper Mississippi to Lake Michigan. His project did not differ materially from that of General Wilson's except that the summit cut across the Chicago divide was to be eight feet deep on a grade of 0.28 feet per mile, with a capacity of 124,000 feet per minute.

In 1883 Mr. G. Y. Wisner, under Major W. H. H. Benyaurd, made a survey between Joliet and LaSalle, and the Wilson project was substantially adhered to.

The canal was examined in 1882, with a view to a slight enlargement as an extension of the proposed Hennepin canal to Lake Michigan. By Act approved April 28, 1882, and ratified by popular vote on November 5, the same year, the State of Illinois ceded to the United States the Illinois and Michigan canal, on condition that it should be enlarged and forever maintained. The Board of Engineers in 1886 decided that the improvement of the river between Joliet and Hennepin was to be preferred, and this cession expired by limitation on November 5, 1887. Meantime the State of Illinois, by Act approved May 31, 1887, ceded to the United States the State works at Henry and Copperas Creek, in order to meet the objection that there would still remain a section of the through waterway under the control of the State of Illinois, in case the United States accepted the cession of the Illinois and Michigan canal. This Act was repealed by an Act of the General Assembly approved June 4, 1889, in force July 1, 1889.

4. HISTORY OF OTHER ILLINOIS WATERWAYS.

Following the Act of Congress of 1822, the State of Illinois, by Act of January 14, 1823, provided for the appointment of a canal commission, and, among other things, instructed it "to invite the attention of the Governors of the states of Ohio and Indiana, and through them the legislatures of their respective states, to the importance of improving and connecting the navigation of the Wabash and Maumee rivers by canal communication."

On February 27, 1837, the State of Illinois passed an "Act to establish and maintain a general system of internal improvements." This Act appropriated \$100,000 for the Great Wabash; \$100,000 for the Illinois river; \$100,000 for the Rock river; \$50,000 for the Kankakee river;

and \$50,000 for the Little Wabash. It also appropriated several million dollars for railways. Further appropriations were made in 1839. These Acts failed to accomplish any substantial results, owing in part to the financial stringency of 1837, and were repealed in February, 1840, leaving the State several million dollars in debt.

In 1847 the State incorporated the Kankakee and Iroquois Navigation and Manufacturing Company, the name of which was changed later to the Kankakee Company. This company extended navigation up the Kankakee river by means of locks and dams to the foot of the rapids at Altorf, twenty-one miles from the junction of the Illinois and Michigan canal, near Dresden, utilizing as part of its system the canal feeder for something more than four miles, and the pool created by the State dam. It made surveys and a project with a view of extending the work to Momence, 47.5 miles from the canal and 105 feet above the same. The Kankakee Company forfeited control of its navigation works in 1882, by reason of non-fulfillment of its charter requirements, and the works have since fallen into disuse and the State has abandoned the Kankakee feeder at Dresden. A survey of the river was made by James Worrell in 1866-7 from Momence to the mouth, as part of General Wilson's investigation of the water route between Lake Michigan and the Mississippi river. Mr. Worrell refers to the feasibility of an improvement of the river and of an extension through the Kankakee country to a junction with the Wabash and Erie canal, thus forming a through route to Lake Erie. The river was further examined and reported upon by the United States. (See Report Chief Engineer, U. S. A., 1879, 80, 84 and 85.) All the reports concur in the feasibility of improving this stream by a system of locks and dams.

In 1866-67 Mr. James Worrell, under General Jas. H. Wilson, made a survey of the Rock river from the Mississippi river at Rock Island to Lake Winnebago, Wisconsin, a distance of 285 miles. He found the route to be entirely practicable, and made a project for its development with locks 200 by 30 by 7 feet, at an estimated cost of \$14,000,000.00.

The Illinois and Mississippi (Hennepin) canal extends from the big bend of the Illinois near Hennepin, in the valley of Bureau Creek and Green river and in the Rock river, to the Mississippi river, a distance of seventy-five miles, with a feeder to the Rock river at Sterling 29 miles long. The canal is 80 feet wide on the surface and 7 feet deep, with locks 170 by 35 feet, and is available for boats 140 feet long, drawing 6 feet of water and carrying 600 net tons of freight. The rise from the Illinois river to the Summit level is 196 feet by 21 locks, and the descent to the Mississippi river is 93 feet by 10 locks; total rise and fall of 289 feet and 31 locks. The Rock river portion was opened to traffic in 1895, and the canal was formally opened October 24, 1907. The first survey for this canal was made by J. O. Hudnutt, civil engineer, for certain parties, in 1866, and was located from the Illinois river opposite Hennepin, to Watertown on the Mississippi, with a feeder from Dixon on the Rock river. Mr. Hudnutt proposed a prism 60 feet wide and 6 feet deep, with locks 150 by 21 feet. The route was again surveyed in 1879 by G. P. Low, under Colonel J. M. Macomb, as part of the northern transportation route to the seaboard, and the project called for a canal prism

160 feet wide and 7 feet deep, with locks 350 by 75 feet. Hudnutt's route was substantially followed. The project was recast in 1874 as a "commercial canal" with locks 170 by 30 feet. The route was surveyed by Hiero B. Herr, under Major W. H. H. Benyaure in 1882, following what is known as the Marais d'Osier route to Albany on the Mississippi river, below Clinton, and supplemental surveys were made in 1885. A board of engineers considered the matter in 1886, and a revised project was submitted in 1888-90, and appropriation was made therefor September 19, 1890. Various changes in plan and location were made, however, in 1891, 1892 and 1896.

In 1868 the State of Illinois appropriated \$35,000.00 to complete the lock and dam at New Haven, on the Little Wabash river, which had been begun by private parties. This dam was two miles above the mouth and extended twenty-six miles from the mouth to Carmi. This work was completed in 1869 and was in use for about one year, when the gates failed to operate, and in 1886 the State appropriated money for removal of the works, and part of the dam was taken out in 1887. The river was examined by the United States in 1893, and considered worthy of improvement up to Carmi.

The Sangamon river was examined under Major W. H. H. Benyaure in 1882-3 as far as Petersburg, 66½ miles from the mouth, with a rise of 68 feet. The stream at low water was found to be navigable for small boats if the channel were properly cleared and the bridges changed. This river was declared to be a navigable stream by Act of the General Assembly of Illinois in 1845 and again in 1882.

The Kaskaskia river has a length of 250 miles and drains an area of about 5,000 square miles. It has been examined 43 miles from the mouth, up to New Athens, where bridges obstruct the further ascent of boats. Appropriations have been made by the United States for removing obstructions. The river was the subject of report in 1888, 1891 and subsequent years. (See report Chief Engineer U. S. A.) In 1881, the Mississippi cut into the bed of the Kaskaskia seven miles above its mouth, and the effect has been to raise the low water stage six or seven feet, thus greatly increasing the depth in the lower reach of the river.

No examination of the Fox river has been found, although the capabilities of this stream should have attracted attention. No reports have been found upon other streams within the State of Illinois. The Mississippi river on the west, the Ohio river on the south, the Wabash river on the east and the lake harbors of the Illinois shore have been the subject of federal examination and appropriations from an early day.

5. RECENT HISTORY.

The deepening of the summit level of the Illinois and Michigan canal in 1866-71, failed to give Chicago more than temporary sanitary relief, and in 1881 the General Assembly required the expedient of pumping works, as already noted. In his annual report for the year ending December 31, 1878, Mr. E. S. Chesbrough, who had been city engineer since 1854, referring to the pollution of the lake from the river, expressed himself as follows: "And yet for this there is no present remedy,

and none apparently within the power and resources of the city in the early future."

The growth of the city had exceeded all expectations, and a great variety of suggestions were made. The urgency of a solution was emphasized by the great down-pour of August 2, 1885, the local flood, reinforced by the Desplaines overflow, sweeping the filth of the city out into the lake and around the water intake two miles from shore. Pollution from this cause had been frequent, but not before so pronounced and startling.

Mr. Ossian Guthrie, Frank W. Reilly, M. D., Assistant Secretary State Board of Health, and Lyman E. Cooley, C. E., examined the situation on behalf of the Citizens' Association, and the report as drawn by the latter was adopted on August 27, 1885, and published by the entire press of Chicago. The solution proposed was a ship canal, ample in capacity to dilute the sewage beyond offense and to carry the flood waters, after diverting the upper Desplaines river to the lake north of the city. Incidentally, the canal would form part of a waterway to the Mississippi and produce a large water power. The matter was vigorously promoted and resulted in the appointment of the Drainage and Water Supply Commission (authorized by the city council, January 27, 1886, amended February 23), consisting of Rudolph Hering, Benezette Williams and Samuel G. Artingstall. This commission made a preliminary report January 30, 1887, but no final report was submitted, owing to the disbandment of the commission November 5, 1887, before all the data were worked up. Some \$65,000.00 had been expended and \$20,000.00 was estimated as necessary to complete the work.

Two solutions were fully developed and disposed of as unsatisfactory and impracticable on account of cost, viz.: sewage disposal in the lakes, and the shifting of the water supply north, and sewage disposal on lands, situated mostly in Indiana. The plan recommended though not fully worked out, was: The diversion of the flood waters of the upper Desplaines valley north of the city; the canal from the Chicago river to Lockport, with a capacity of 600,000 cubic feet of water per minute, and a branch canal from the Calumet river through the Sag, with a capacity of 60,000 cubic feet per minute. Much of the material gathered found its way into special publications which are later referred to.

Two bills were introduced in the General Assembly of Illinois in 1887, and one of these with amendments was favorably reported by the joint committee. It failed to pass, and on May 26-31, a joint resolution provided for a committee of five to consider "the subject of the drainage of Chicago and its suburbs," and to report to the next General Assembly. The committee consisted of the Mayor of Chicago as chairman, Hon. John A. Roach, two Senators, B. A. Eckart of Chicago and Andrew J. Bell of Peoria, and two Representatives, Thomas C. McMillan of Chicago and Thomas H. Riley of Joliet. John P. Wilson was employed as counsel and Lyman E. Cooley as engineer. The report was submitted to the General Assembly, February 1, 1889, in the form of a bill, and, as amended was passed as the "Act to create sanitary districts and to remove obstructions in the Desplaines and Illinois rivers," approved May 28, 1889, in force July 1, 1889.

A petition for the organization of the sanitary district of Chicago was filed with the county judge on August 15, 1889, and the commission provided for in section 1 of the Act, fixed the boundaries of the district on October 14, 1889, said boundaries covering the then city of Chicago and five adjacent municipalities, and other outlying territory, an area of about 185 square miles.

The district was adopted by popular vote (70,000 to 200) at the general election of November 5, 1889, and trustees were elected at the special election of December 12. The board organized January 12, 1890, and the Supreme Court affirmed the validity of the Act on June 12, 1890.

The essence of the sanitary requirements is expressed in the following excerpts from the law:

Section 20 states: "Any channel or outlet * * * * shall be of sufficient size and capacity to produce a continuous flow of water of at least 200 cubic feet per minute for each 1,000 of the population of the district drained thereby, and the same shall be kept and maintained of such size and in such condition that the water thereof will be neither offensive or injurious to the health of the people in this State." Section 23 states: "Such channel shall be made and kept of such size and in such condition as will produce and maintain at all times a continuous flow of not less than 20,000 cubic feet of water per minute for each 100,000 of the population of such district."

Section 23 states further: "Such channel shall be constructed of sufficient size and capacity to produce and maintain at all times a continuous flow of not less than 300,000 cubic feet of water per minute * * * * and if any portion of any such channel shall be cut through a territory with a rock stratum * * * * such portion of said channel shall have double the flowing capacity above provided for."

The waterway provisions are expressed in the following excerpts:

Section 23 provides in rock for "a width of not less than 160 feet at bottom * * * * a depth of not less than 18 feet of water," and "if at any time the General Government shall improve the Desplaines and Illinois rivers, so that the same shall be capable of receiving a flow of 600,000 cubic feet per minute or more from said channel, and shall provide for the payment of all damages which any extra flow above 300,000 cubic feet of water per minute from such channel may cause to private property so as to save harmless said district from all liability therefor, then such Sanitary District shall, within one year thereafter, enlarge the channel leading into said Desplaines and Illinois rivers from said district, to a sufficient size and capacity to produce and maintain a continuous flow throughout the same of not less than 600,000 cubic feet of water per minute, with a current of not more than three miles per hour, and such channel shall be constructed on such grade as to be capable of producing a depth of water not less than 18 feet throughout said channel, and shall have a width of not less than 160 feet at bottom."

Section 24 is as follows: "When such channel shall be completed and the water turned therein to the amount of three hundred thousand cubic feet of water per minute, the same is hereby declared a navigable stream, and whenever the General Government shall improve the Desplaines and Illinois rivers for navigation, to connect with this channel, said General Government shall have full control over the same for navigation purposes but not to interfere with its control for sanitary or drainage purposes."

Section 27 states: "If any such channel receives its supply of water from any river or channel connecting with Lake Michigan, it shall be construed as receiving its supply of water from Lake Michigan."

Work on the main channel or "outlet" was inaugurated at the Cook and Will county line on September 3, 1892. Under date of May 8, 1899, the Secretary of War and the Chief Engineer, U. S. A., granted

a permit to divert the waters of the Chicago river into the main channel, subject to the requirements of navigation in said river, acting under general authority of section 10, River and Harbor Act, approved March 3, 1899. On May 9, 1899, the Governor appointed the special commission required by section 27 of the Sanitary District Act, and on January 17, 1900, the commission reported that "The work is substantially completed and meets the requirements of the law * * * * * and we recommend the granting of the final permit," which was at once issued, and the bear-trap dam was lowered and the flow started at 11:15 a. m. The special commission filed an elaborate report June 14, 1900.

The main channel (at date of opening) extended from the junction with the West Fork at Robey street, 28.03 miles to the controlling works near Lockport. The earth section extends from Robey street 13.10 miles to Willow Springs, with bottom width of 202 feet and surface width of 300 feet, the grade at Robey street being 24.48 feet below Chicago datum, and the declivity 1-40,000. The earth section was completed from Willow Springs to Summit 5.8 miles, this being territory with a "rocky stratum," but a width of 92 feet remains to be excavated to complete the channel for the 7.80 miles between Summit and Robey street. The rock section extends from Willow Springs 14.93 miles to the controlling works near Lockport, with a bottom width of 160 feet and top width of 162 feet between the rock and masonry sides, the declivity being 1-20,000 and the grade at the controlling works 30.1 feet below Chicago datum. All the bridges are swing or bascule bridges and have been built for the completed channel, and the right of way is provided and the work laid out therefor.

The Desplaines river opposite the main channel was re-located for thirteen miles and restrained by embankment for twenty miles, between Summit and Lockport. Work was done to facilitate the passage of the water over the eight miles between the controlling works and the head of Lake Joliet. Work was also done in the Chicago river to facilitate the passage of the preliminary volume of 300,000 cubic feet of water per minute. Work was begun, by arrangement between the district and the city, on conduits for circulating the waters of the South Fork and the North Branch.

A preliminary determination of the capacity of the completed channel was made by the expert commission in 1901, (See page 7250, June 19, of Proceedings of the Board of Trustees of the Sanitary District of Chicago; report submitted April 23, 1901), as follows:

At low water in lake, with channel so fed as to give a depth of 24.4 feet at Willow Springs—836,280 feet per minute.

At mean lake level, taken at 1.6 feet above low water—911,160 feet per minute.

At high lake level, taken at 3.2 feet above low water—989,280 feet per minute.

The Sanitary District Act (Section 23) also provides:

"The district constructing a channel carrying water from Lake Michigan, of any amount authorized by this Act, may correct, modify and remove obstructions in the Desplaines and Illinois rivers wherever it shall be necessary so to do, to prevent overflow or damage along said river, and shall remove the dams at Henry and Copperas Creek in the Illinois river before any water shall be turned into said channel."

The Board of Canal Commissioners of the Illinois and Michigan canal are also to remove the dams if at any time they find sufficient water to give six feet at low water on the miter sill of the lower lock at LaSalle. The Supreme Court in 1900 held that the authority to remove was not mandatory but permissive.

A contemporaneous Act, "An Act in reference to the improvement of the Illinois and Desplaines rivers, etc.," approved June 4, 1889, in force July 1, 1889, also provided for the removal of the dams by the canal commissioners under certain conditions, and changed the Act of cession of 1887, to the General Government.

Section 4 reads as follows: "The State of Illinois bases this Act of cession upon the condition that the plan of improving the Illinois river below LaSalle by slack water maintained by dams and locks, be changed to a plan of improvement by means of an open channel in conjunction with a water supply from Lake Michigan."

The General Assembly of 1889, in addition to its sanitary and waterway legislation and in interpretation thereof, passed a joint resolution. The first resolution reads as follows:

"That it is the policy of the State of Illinois to procure the construction of a waterway of the greatest practical depth and usefulness for navigation from Lake Michigan via the Desplaines and Illinois rivers to the Mississippi river, and to encourage the construction of feeders thereto of like proportions and usefulness."

In the second resolution the United States is requested to change its plan of improvement from locks and dams to that of an open channel, "in such manner as to develop progressively all the depth feasible by the aid of a large water supply from Lake Michigan at Chicago."

In the third resolution, the United States is requested to aid in the construction of a channel 22 feet deep between Lake Michigan and Lake Joliet, and to project a channel 14 feet deep thence to LaSalle, "all to be designed in such manner as to permit future development to greater capacity."

In the joint resolution of May 27, 1897, the foregoing propositions are more elaborately and emphatically stated.

The General Assembly on June 14, 1895, by practically a unanimous vote, passed a broad and far-reaching measure, entitled: "An Act to promote the construction of waterways," but this was vetoed by Governor Altgeld, June 26, 1895.

The issues as developed at that time were threshed out at the Illinois River Improvement Convention, Peoria, October 11-12, 1887. "The Lakes and Gulf Waterway," published by the Citizens' Association of Chicago, January, 1888, was prepared by the authority of the executive committee. In response, Congress, by Act approved August 11, 1888, authorized a survey for a channel "not less than 160 feet wide, and not less than 14 feet deep," from LaSalle to Lake Michigan. The official report of Captain W. L. Marshall, the officer in charge, was submitted February 28, 1890. It was not responsive to the spirit of the Act, and breathed an adverse spirit. It was reviewed at length by the chief engineer of the Sanitary District in the "The Lakes and Gulf Waterway as Related to the Chicago Sanitary Problem," August, 1890, published by subscription May 1, 1891. In successive annual reports, up to 1899,

Captain Marshall makes adverse comment upon the Illinois program. The River and Harbor Act, approved June 3, 1896, provides for a further examination of "the upper Illinois river and the lower Desplaines river," and a report is submitted by Captain Marshall on January 27, 1897.

In 1895 the engineering department of the Sanitary District of Chicago completed studies of the Desplaines and Illinois rivers, and projected a waterway from the end of the sanitary canal at Lockport to the Mississippi river. The depth of the sanitary canal was to be carried to Lake Joliet, and 16 feet thence to Utica, with the locks so treated as to admit of a future channel of 24 feet, thence 14 feet in an open river to Grafton. The estimated cost was \$25,000,000.00. Five locks were provided between Lockport and Utica, in place of sixteen in the Marshall project and nine in the project recently submitted.

"The Deep Waterways Convention" was held at Peoria, October 10-11, 1899. In response to the sentiment developed, the River and Harbor Act, approved June 6, 1900, instructed the Board of Engineers which had been appointed under the Act of March 3, 1899, to make surveys and estimates for seven and eight feet, to also report upon the feasibility of depths up to 14 feet. This board (Col. J. W. Barlow, chairman) reported November 17-18, 1900, that a navigable depth of 14 feet was feasible. The issues involved were heard by the River and Harbor Committee on December 11, 1900, and the Act, approved June 13, 1902, (the bill for 1901 failed of passage) appropriated \$200,000.00 for final surveys with project and estimates, for a navigable depth of 14 feet between the end of the sanitary canal at Lockport and the city of St. Louis, a board of engineers, to be appointed, and the Mississippi River Commission, to make the examination and report. The report (Col. O. H. Ernst, chairman) was submitted August 26, 1905, (H. R. 263, 59th Cong., 1st Ses.)

On September 5, 1888, and subsequent dates, a series of papers were read before the Western Society of Engineers on "The Levels of the Lakes as affected by the Proposed Lakes and Gulf Waterway," published in the Journal of the Association of Engineering Societies, March, 1889, and reprinted by the Citizen's Association of Chicago.

At the request of the secretary of the American Society of Civil Engineers, who had been asked by the chief engineer of the Montreal Harbor Commission of Canada, to suggest the subject, the Chief Engineer, U. S. A., ordered observations of the outflow of the Niagara river, in November, 1891, and these were continued in 1892. In November, 1894, L. E. Cooley, trustee of the sanitary district, submitted to the attorney of the Lake Carriers' Association a "Brief on Lake Level Effects on Account of the Sanitary Canal of Chicago." On petition of commercial bodies about the great lakes, in which the Chicago board of trade joined, the secretary of war, on.....1895, constituted a board of officers, U. S. A. (General O. M. Poe, chairman) to consider the effect of the proposed diversion of waters at Chicago. The report was submitted.....1895.

The U. S. Board of Engineers on Deep Waterways made observations on the outflow of the Niagara river in 1897-8, and the U. S. Lake Survey has since made observations on the outflow of the St. Clair river.

By Act of June 13, 1902, the International Waterways Commission was authorized, (General O. H. Ernst, chairman, American Section) and this body has taken the question of the diversion of waters under advisement.

The State Board of Health gave special attention to the sanitary problems of Chicago from and after 1881, and published important conclusions regarding purification of sewage in running streams in 1886. In 1887-9 elaborate chemical studies were made of the stream between Lake Michigan at Chicago and the Mississippi river at St. Louis, and a special report was issued, "Water Supplies of Illinois," April 3, 1889. The State board continued its work and published a further compilation in 1903.

In 1899 and in 1900, before and after the opening of the sanitary canal, elaborate biological examinations were made under the direction of the Health Commissioner of Chicago, by the coöperation of the Health Department of Chicago, the Chicago University, and the University of Illinois. The report is dated December 1, 1902, (Sanitary District, December, 1902) and is entitled, "Streams Examination (Chemic and Biologic) between Lake Michigan at Chicago and the Mississippi river at St. Louis."

On January 17, 1900, the original bill of complaint was filed in the United States Supreme Court in the case of "State of Missouri against State of Illinois and the Sanitary District of Chicago," to restrain the discharge of the sewage of Chicago through an artificial channel into the Desplaines river in the State of Illinois. The demurrer of defendant was overruled and leave granted to answer complaint. Several years were taken and a large expense incurred in preparing the case, and the complaint was finally dismissed on February 19, 1906.

The court in its opinion, among other things, says:

"Some stress was laid on the proposition that Chicago is not in the natural watershed of the Mississippi, because of a rise of a few feet between the Desplaines and the Chicago rivers. We perceive no reason for a distinction on this ground. The natural features relied upon are of the smallest. And if under any circumstances they could affect the case, it is enough to say that Illinois brought Chicago into the Mississippi watershed, in pursuance not only of its own statutes, but also of the Acts of Congress of March 30, 1822, C. 14, 3 St. 659, and March 2, 1827, C. 51, 4 St. 234, the validity of which is not disputed. *Wisconsin vs. Duluth*, 96 U. S., 379. Of course, these Acts do not grant the right to discharge sewage, but the case stands no differently in point of law from a suit because of the discharge from Peoria into the Illinois, or from any other or all the other cities on the banks of that stream."

And the court might have added: "The development of the canal at Chicago simply expresses the larger demands and the greater resources of the present time."

The lakes and gulf waterway has been the subject of popular consideration at many conventions.

The Illinois River Convention, Peoria, Ill., October 11-12, 1887, and October 10-11, 1899.

Western Waterways Convention, Memphis, October 20-21, 1887; Vicksburg, October 22-23, 1895; Memphis, November 14-15, 1900.

International Deep Waterways Association, Toronto, Ontario, September 17-20, 1894; Cleveland, Ohio, September 24-26, 1895.

Trans-Mississippi Commercial Congress, Houston, Texas, April 17-20, 1900; Cripple Creek, Colorado, July 17-20, 1901; St. Paul, Minnesota, August 19-21, 1902; Kansas City, Mo., November 20-23, 1906.

National Farmers' Congress, Chicago, November 11-12, 1887.

Lakes and Gulf Waterway Convention, St. Louis, Mo., November 15-16, 1906.

Lakes-to-the-Gulf Waterway Convention, Memphis, Tenn., October 4-5, 1907; Chicago, Illinois, October 7-8-9, 1908.

In addition to the titles mentioned in the text, the following are referred to:

Testimony before the Joint Committee of the General Assembly, April, 1887, printed by the Citizens' Association of Chicago.

"The Hennepin Canal," Chicago Morning News, April 7, 1886, Chicago Tribune, December 11, 1886.

"Future of Chicago," Chicago Morning News, January 1, 1887.

"The Waterway between Lake Michigan and the Mississippi river by way of the Illinois river," read before the Engineers' Club of St. Louis, May 30, 1888, by Robert E. McNath, reprinted from Journal of Association of Engineering Societies by Citizens' Association of Chicago.

"Vision of Empire," Chicago Morning News, February 18, 1889.

"The Sanitary and Ship Canal of Chicago; Solution of the Sanitary Problem," read before the National Conference of State Boards of Health, at Chicago, June 10, 1896, printed in proceedings.

Report of the "Pure Water Commission," (intercepting sewer system) February 8, 1897. Proceedings of city council March 1, 1897.

6. GROWTH IN IDEAS.

A canal at Chicago was obvious to the first white man that crossed the Chicago Divide. The early promotion was for a "ship canal," something larger than a horse-boat canal. This meant a depth of 9 to 10 feet, or that of the original St. Lawrence and Welland canals. The depths naturally available in the intermediate channels of the Great Lakes and the St. Lawrence, did not exceed 10 feet, and all the original ideas were based on this limit.

When Mr. Charles T. Harvey (still living) projected the first canal at Sault Ste Marie (built 1852-5 with locks 350 by 70 feet and a depth of 12 feet, thus anticipating some future development, the project was the subject of protest by the then largest vessel owner of the Great Lakes, Mr. E. B. Ward of Detroit.

When the Canadian authorities projected the enlarged Welland and St. Lawrence canals in 1871, they found but one commercial body about the Great Lakes to suggest lock dimensions as large as those adopted, or 270 by 45 by 12 feet. In 1875, the projected depth was increased to 14 feet.

When Gen. O. M. Poe projected 24 feet for the last lock built at Sault Ste Marie and opened in 1895, he found no marine interests that desired more than 18 feet, and had to content himself with 21 feet.

It was not until 1858 that 12 feet was available in the intermediate channels of the Great Lakes, and 13 feet was not available until 1871. In 1874-83 the channels were deepened to 16 feet, and to 20 feet by 1895.

In the St. Lawrence below Montreal, 15 feet was available by 1852, 20 feet in 1869, 22 feet in 1878, 25 feet in 1882, and 27½ feet by 1890, and greater depths are now being developed. The Welland canal was opened for 12 feet in 1883, and 14 feet in 1888.

The Illinois and Michigan Canal had been opened but ten years when John B. Preston made his project (1858) for a steamboat canal 7 feet deep, with a water supply from Lake Michigan for the improvement of the alluvial river below Utica. After another ten years this project, minus the water supply, took root in the official mind, and only since 1900, has the idea of deep water, not less than 14 feet, to be obtained by the aid of a water supply from Lake Michigan, been tolerated, although the General Assembly of Illinois declared this to be the policy of the State in 1889. That Chicago and Illinois should attempt something that looks to the future—that will not be obsolete before it can be completed—is made the subject of prejudice. The authorities seem to be more concerned in framing an indictment than in finding remedies which will conserve other vested interests, and permit the development of a waterway project, continental in scope and the greatest of a century. The issue is a waterway from the lakes to the gulf, as great as the physical conditions will permit, not limited in its future development by the works which it may now be expedient to construct, and this may be had without damage to any vested interests. Against this proposition is conservatism, and the prejudice of centralized authority which objects to the projects of states and localities, even though they be acting within their sovereign rights. The history of the Illinois waterway is a history of bold and far-reaching ideas and official blight.

Part II. Divisions of Route.

7. THE CHICAGO DIVIDE.

The Chicago Divide as herein used, covers the old outlet from the head of the pool known as Lake Joliet and immediately below the city of Joliet, to the present shore line of Lake Michigan, a distance of thirty-nine miles by the route of the sanitary canal, prolonged to the Lake Shore, and some four miles farther by the branch valley of the Sag, turning the south end of the Blue Island ridge.

The site of Chicago is the floor of an old bay, extending in ten miles to Summit. Rock domes come to the surface at Fullerton avenue on the north, Western avenue on the west, and Archer road on the south; and within these limits are deep alluvial clays that furnish uncertain sites for tall buildings, but these thin out over the compact drift clays toward Summit. All the varying material of an ancient stream-bed overlies the uneven rock surface of the Desplaines valley for the eleven miles between Summit and Sag, and for the two miles farther to the rock floor above Lemont. Half of the sixteen miles over the rock bed to Lake Joliet has a slope of one or two feet per mile, and the lower half, eight to ten feet per mile to the pool level 76.5 feet below Lake Michigan. At the head of this declivity are the pot-holes of the ancient rapids, and at the foot is the pool dug twenty-five feet or more deep in the Cincinnati limestone, overlying the more resisting Niagara limestone, the mother rock of the Chicago Divide.

The old shore line of the Calumet region lies at Riverdale, six miles from the present lake shore; thence is nineteen miles of old stream-bed through the Sag valley, similar to the Desplaines valley below Summit. The northern drainage of the Valparaiso moraine, from opposite Michigan City, gathers behind the old forty foot beach ridge, flowing westerly and turning at Blue Island to cross the old shore at Riverdale. The Calumet formerly continued east of the State line, but in historic times it broke across into the outlet of Lake Calumet and developed its present course to the lake. The Calumet region in Illinois and Indiana is generally low-lying, and the southward shore-drift accumulated in broad ridges of beach material. The modern lake is repeating the past, and winds drive the finer sands away in dunes, especially around the easterly head of the lake.

The Chicago basin proper, east of Summit and north of Eighty-seventh street, including the shore drainage to the north limit of Lake Forest, has an area of 329 square miles (includes original sanitary district, except west of Summit, and the north shore annex.)

The Desplaines river basin north of Summit has an area of 634 square miles, and 776 square miles to the head of Lake Joliet, omitting the drainage of Hickory Creek.

The Calumet basin south of Eighty-seventh street, including the Sag and the shore drainage to twelve miles east of the State line, has an area of 825 square miles, 473 of which lie in the state of Indiana.

The total of these several basins is 1,930 square miles. If these streams should all yield flood waters in proportion to that from the Desplaines river, and were all gathered in one outlet at Lake Joliet, the aggregate flood would be 28,400 second-feet on the basis of the great flood of 1881, at Riverside, assuming the normal basin ratios.

Such considerations have led to the proposed diversion of the upland waters of the Desplaines and Calumet, in all the projects for the drainage of Chicago and its environs. Thus a separate course was laid out and constructed for the Desplaines river, opposite the sanitary canal between Summit and Lockport.

The Sanitary District of Chicago, as originally organized has an area of 185 square miles and a population of 1,687,972, by the federal census of 1900.

The Act of the General Assembly, approved May 14, 1903, in force July 1, 1903, annexed the north shore, in Cook county, with an area of 78.6 square miles and a population of 40,280 in 1900; also the Calumet region with an area of 94.5 square miles, and a population of 97,324 in 1900. The present district has therefore an area of 358.1 square miles, and a population of 1,825,576 by the census of 1900.

The Expert Commission of 1901 proposed also to annex an area of 16.6 square miles adjacent to the lake shore in Lake county, Illinois, and extending to the north limits of Lake Forest, all of which can be drained into the channels of the Sanitary District. This territory had a population of 7,190 in 1900. Farther north and along the shore to the Wisconsin line, is an additional population of 12,600, which cannot be made tributary. The total north of the present district in Illinois is 19,790. East of the State line in Indiana, on an area of 47.5 square miles, is a population of 21,034 in 1900. The total population of the Illinois and Indiana front, outside of the present Sanitary District, is therefore 40,824, and the grand total is 1,866,400.

The main channel of the Sanitary District, as it existed at the time that it was opened, January 17, 1900, is described under topic 5. There has recently been completed an extension of the channel for 3.3 miles from the controlling works to the upper limits of Joliet, and the Chicago river is in process of widening to a uniform width of 200 feet and a central depth of twenty-six feet, with bascule bridges throughout, and the tunnels beneath the river are being lowered. Work has also been done in the pool of dam No. 1 at Joliet, and on the conduits and pumping works leading to the South Fork at Thirty-ninth street, and to the North Branch on Lawrence avenue. The average yearly flow through the main channel, in feet per minute, has been as follows:

1900, 188,136.	Average of 49 weeks.
1901, 242,323.	Average of 52 weeks.
1902, 257,006.	Average of 52 weeks.
1903, 299,299.	Average of 52 weeks.
1904, 290,000.	Average of 52 weeks.
1905, 268,829.	Average of 52 weeks.
1906, 267,903.	Average of 51 weeks.
1907, 307,186.	Average of 52 weeks.

The following table gives the characteristic reaches from Lake Michigan at the mouth of the Chicago river, to Brandon's bridge at the head of Lake Joliet:

Locality.	Distance— miles.	Width of channel—feet.	Remarks.
Lake Michigan	0.0	.....	Head of pier.....
South Fork Junction.....	5.37	200	.....
Robey st.....	6.02	200	Canal entrance.....
Summit	13.82	110	Bottom width in earth
Willow Springs.....	19.12	202	Bottom width in earth
Sag Junction.....	24.20	160	Rock cut.....
Controlling works.....	34.05	160	Rock cut.....
Water Power Station.....	36.05	160	Least width.....
Dam No. 1, Joliet.....	38.70	.....	.....
Head Lake, Joliet	41.30	.....	Brandon's bridge

The quantities handled in excavating the main channel, the river diversion, and the Chicago river, are as follows:

Rock, in place, cubic yards	14,388,118
Earth, cubic yards	32,962,772
Masonry, cubic yards	632,244

The total expenditures of the Sanitary District for all purposes, to December 31, 1906, are \$52,698,024.98.

8. THE UPPER ILLINOIS.

The Upper Illinois division covers 56.2 miles from the head of Lake Joliet at Brandon's bridge, on the Desplaines river, to the head of the Henry pool at Utica bridge, though geographically, the Illinois river is formed by the union of the Desplaines and Kankakee rivers, thirteen miles below Brandon's bridge.

The valley of erosion headed for Lake Michigan, is a case of arrested development, with declivities adjusted to the resisting rock stratification. Through the valley bottom, the modern stream has defined its course, and a normal stream-bed has developed with true flood plains, though unfilled remnants of an older and greater stream-bed still exist, showing progressive shrinkage in the survey period. These old pools still aggregate a length of twenty-two miles, and still carry a good depth of water—Lake Joliet, at 76.5 feet below Chicago datum, (low water of 1847 in Lake Michigan), Lake DuPage at 90.2 feet, and Marseilles pool, originally above the Kickapoo reef, but now controlled by the dam, at 101.4 feet. All elevations refer to the low water of 1883.

Between the lakes, Joliet and DuPage, are sharp pitches, Treat's Island, and the dump at the DuPage river mouth, and again over Cincinnati limestone, below Lake DuPage, and opposite the mouth of the Kankakee. The Marseilles dam is 25.8 miles below the mouth of the Kankakee, and 38.8 miles below Brandon's bridge. It is at the head of a descent, in the coal measures, dropping some twenty-eight feet in six miles, and at Ottawa, at the mouth of the Fox, the level is 132.2 feet below Chicago datum. From Marseilles to Utica bridge is 17.4 miles, the bed below the rapids in St. Peters sandstone, with a fall of about half a foot per mile to the lower end of Buffalo Rock; thence some

twelve feet in four miles, to Starved Rock, the declivity terminating on the water line outcrop 0.3 miles above Utica bridge. The original low water elevation (1871) at this point, was approximately, 147 feet below Chicago datum; but the pool level produced by the dam at Henry, is 142.2 feet below Chicago datum, (low water of 1883) with a declivity of some 0.6 feet in the following two and a half miles, the channel at the head of the pool having greatly silted in recent times.

From the head of Lake Joliet to the head of the pool at Starved Rock, also the head of the alluvial valley of the lower Illinois, is then 55.9 miles, with an original fall of 70.5 feet, and a present fall of 4.8 feet less. The river throughout this distance has an average width of about 600 feet, generally subdivided by islands below Ottawa, and the bank heights vary from eight to twenty-three feet. These banks are overflowed, more or less, in two years out of three.

A flood record was kept at Morris by Mr. L. W. Claypool, for the fifty-six years, 1834 to 1890. This shows twenty years in which the river was not out of banks, and fifty-three floods in the other thirty-six years. Of these, seventeen exceeded seventeen feet above low water, nineteen ranged from fourteen to seventeen feet, and seventeen ranged from ten to fourteen feet. The time out of banks averaged nine days for the flood years.

Mr. Claypool's estimate of the overflowed lands above Marseilles dam, in LaSalle and Grundy counties, is still the most satisfactory, and these lands cover seventy-five per cent of the values between Joliet and Utica. The estimate is as follows:

Under 10 feet	905 acres 11 per cent
From 10 to 14-15	4,050 acres 52 per cent
14-15 to 18	2,085 acres 27 per cent
18 to 20 feet	739 acres 10 per cent

Total	7,779 acres 100 per cent
(20 to 23 feet 390 acres.)	

On a comparable basis, the total overflowed lands in Will county, were estimated at 1,000 acres, 250 of which are marginal lands of little value, and the remainder chiefly in Treat's Island, and the bottoms of DuPage river and Jackson creek.

The lands between Marseilles and Utica, for the equivalent stage of twenty feet at Morris, have been estimated at 3,050 acres, about two-thirds of the area being in the four miles below Buffalo Rock, and more affected by back water from the lower river than by head water floods. These lands are largely infertile.

The value of all these lands was carefully estimated in 1890, as follows: 11,829 acres, \$618,240.00.

Mr. Claypool's plane of reference happens to be an even hundred feet below Chicago datum, by the last survey, and 0.3 feet above the low water of 1883, at Morris bridge (built in 1856) and 0.66 feet above the low water of 1887, and less than a foot above the lowest known water. The highest known flood at Morris was twenty-three feet, and was observed by William Marquis, in March, 1830. The Claypool record begins with Mr. Claypool's arrival in Morris in March, 1834. In the thirty-four years, (1834-67), thirteen floods occurred exceeding seven-

teen feet, and seven of these ranged between 19.5 and 20.5 feet. The four notable floods in the twenty-two following years, (1868-89) all ranged between seventeen and eighteen feet, the excessive height of 1883 being due to the breaking of the ice gorge and the great dam at Wilmington, and the loosing of the waters stored in the twelve mile pool above. The two most notable floods since 1890 are, 1892 at 20.6 feet, and 1904 at 19.2 feet.

Of the fifty-three floods, from 1834 to 1890, thirty-eight have occurred in the three months, February, March and April, the majority being identified with the spring breakup. The Kankakee usually breaks up and runs out before the ice moves at Morris and at other points in the Upper Illinois, thus producing ice gorges and abnormal stages of water. Such action has been less frequent since the shores and islands were cleared of their timber.

The ice flood of February, 1887, was one of the four notable floods in the 1868-89 period, and its volume was carefully estimated from the heights on dams, as follows:

	Second feet
Joliet, Desplaines river	5,575
Wilmington, Kankakee river	25,225
Marseilles, Illinois river	45,000
Dayton, Fox river	13,680
Ottawa, (sum of the above)	58,680
LaSalle, estimated	60,000

The greatest flood at Joliet in thirty-three years prior to 1890, was estimated at 6,550 feet. The greatest flood at Wilmington, in the nineteen years prior to 1890, (ice gorge flood of 1883 excepted) was estimated at 35,600 second feet. The flood of 1887 was considered extraordinary for the Fox.

Full measurements made at Morris after 1890, indicate that the ice flood of 1887, was abnormally high by about two feet, or that the estimated volumes from the dams were short by fifteen to twenty per cent, which is not probable.

The flood of 20.6 feet at Morris, in May, 1892, is probably the greatest in the historic period, that of March, 1830, being no doubt abnormal from ice effects. This flood was measured by Charles L. Harrison, Assistant Engineer, Sanitary District of Chicago, on May 6, and the volume found at 73,730 second feet. All the available data were reduced for the Sanitary District by James A. Seddon, in 1901, and the equivalents for Morris deduced as follows: (Claypool datum.)

70,000 second feet	20.30 feet in height
65,000 second feet	19.47 feet in height
60,000 second feet	18.60 feet in height
55,000 second feet	17.68 feet in height
50,000 second feet	16.70 feet in height
45,000 second feet	15.65 feet in height
40,000 second feet	14.52 feet in height
35,000 second feet	13.29 feet in height
30,000 second feet	11.94 feet in height
25,000 second feet	10.43 feet in height
20,000 second feet	8.79 feet in height
15,000 second feet	6.92 feet in height
10,000 second feet	4.79 feet in height

The basin areas of the Upper Illinois are as follows:

		Distance from Brandon's Bridge.
Desplaines R., 1392 sq. mi.	} 6540 sq. mi	13 mi.
Kankakee R., 5148 sq. mi.		
Morris	7300 sq. mi.	22.7 mi.
Marseilles	7500 sq. mi.	38.8 mi.
Ottawa (Fox R.)	10230 sq. mi.	46.2 mi.
Utica Bridge	10365 sq. mi.	56.2 mi.

The extreme flood expectation in the Morris-Marseilles reach, is 70,000 second feet, taking the basin as normal. The flood of 1892 seems to have reached the limit for streams in this region of the country.

The natural low water volume of the Illinois at Morris is nominal, not exceeding 250 to 350 second feet in 1887, practically at extreme low water, after allowing for canal water from Lake Michigan. A measurement of 456 second feet was made on the Kankakee river near its mouth, in September, 1867. Extreme low water at Wilmington for twelve years, 1871-83, was estimated at 420 second feet. The Desplaines river practically goes dry above Joliet. The Mazon was dry in 1867. The Fox measured 526 second feet in September, 1867. The canal authorities have measured a low water of 633 feet at LaSalle.

Assuming an ordinary low water volume of 1,000 second feet, the effect of introducing 10,000 second feet from Lake Michigan, at Morris, will be to raise the water 5.2 feet above the Claypool plane, and for 14,000 feet to 6.9 feet.

Extreme floods may be assigned to two causes; heavy winter snow on a frozen ground surface, produces a great breakup rise, followed by extreme low water, as in 1867 and 1887. Again, long continued rains fill the ground and marshes to overflowing and the excess runs away in a great flood, as in the several great floods of May and June. In long continued dry periods the storage of marshes and ponds is exhausted, and as the sub-soil is generally impermeable, extreme low water follows. In ordinary years, the floods are moderate and the low water volume well sustained.

It is evident that any improvement for navigation should modify the regimen of the stream as greatly as possible, rather than as little as possible, as in all official projects. In adapting the Mohawk river (N. Y.) to a deep-water navigation, the Board of Engineers on Deep Waterways, (1897-1900) projected a depth of thirty feet, even for a navigable limit of twenty-one feet, in order to bring flood velocity and slope within moderate limits. In like manner, the capacity of the prism in the Upper Illinois is conditioned by flood volumes, without regard to the depth required for navigation. A project developed on such principles, not only provides a deep water channel, but substantially does away with overflows, and makes possible water power development.

9. THE LOWER ILLINOIS.

The Lower Illinois river is 227.5 miles in length from the Utica bridge to the mouth, not greatly exceeding the length of the valley. The width is generally 600 to 700 feet, expanding in the lower third of the

course to a width of over 1,000 feet as the mouth is approached. The bank height ranges from eight to fifteen feet and averages about 11.5 feet, or about half the height of the greatest floods, like those of 1842 and 1858, which covered from 600 to 700 square miles of bottoms. The original low water declivity was normally twenty-seven to twenty-eight feet, and in notable floods, twenty-eight to thirty feet, (below LaSalle), varying greatly with the relative stages in the Illinois and in the Mississippi.

The Wilson report of 1867 says: "With a sluggish current * * * the river wanders through a valley of swampy land, varying in width from one and a half to six miles," and again, "the straight reaches are almost invariably deep with a muddy bottom, the shallows occur at elbows, at confluent channels and at the mouth of creeks." The report of 1868 states: "The depths are reduced almost every season, upon the shoals in the bed of the stream, until they do not exceed an average of twenty inches, thus in fact suspending navigation for periods ranging from sixty to ninety days." The report of 1890 states that the bottom lands are "cut up by numerous sloughs, lagoons and ponds;" and again, "at about the nine foot stage * * * the basins and lagoons begin to fill, at ten to eleven feet the lowest areas, worthless for cultivation, begin to be submerged, and at about the twelve foot stage overflow begins to become widespread. At about the sixteen foot stage probably eight-tenths of all lands submerged at extreme floods are covered with water."

Every evidence shows that the low grade of the Lower Illinois is inherited from the mighty stream of the past, and that the ancient stream-bed is under transformation to the requirements of the present local drainage, a process involving geologic time. The detritus from tributaries has crowded the modern stream toward the opposite bluff, narrowed its width and steepened the slope, and has caused ridges of higher lands across the bottoms, leaving remnants of the old stream-bed in intermediate reaches and lagoons and ponds in the inter-spacial areas. The contributions have been insufficient to build the bottoms to much more than half the height of the flood plain for normal alluvial rivers, and the bank-full capacity is but a minor fraction, one-third to one-fourth the volume, of notable floods. A study of the evolution of the stream makes clear its similar character among western rivers.

Drainage Divisions—Lower Illinois River.

Division.	Drainage.	Area Square Miles.		Per cent.	Length of division—miles.
		Partial.	Total.		
Upper Illinois	Above Utica.....	10,365	.....	.....	.....
	Vermilion river.....	1,317	.....	.....	.....
	Other drainage.....	165	11,847	42.4	(6.5)
Upper Division.....	Bureau creek	480	.....	.....	.....
	Kickapoo creek	310	.....	.....	.....
	Mackinaw river.....	1,217	.....	.....	.....
	Other drainage	1,730	3,737	13.4	103.4
Middle Division.....	Spoon river.....	1,870	.....	.....	.....
	Sangamon river.....	5,670	.....	.....	.....
	Crooked creek.....	1,385	.....	.....	.....
	Other drainage.....	320	9,245	33.1	36.0
Lower Division	Indian creek.....	290	.....	.....	.....
	McCees river.....	472	.....	.....	.....
	Mauvais Terres.....	275	.....	.....	.....
	Apple creek.....	525	.....	.....	.....
	Macoupin creek.....	985	.....	.....	.....
	Other drainage	538	3,085	11.1	81.6
Total .....	.....	.....	27,914	100.0	227.5

The accompanying table shows that 42.4 per cent of the basin lies above LaSalle-Peru and virtually pertains to the upper river. The upper division of the lower river, above Havana and nearly half the total length, receives the drainage from only 13.4 per cent of the basin, the most considerable tributary being the Mackinaw. The middle division receives 33.1 per cent of the drainage in a length of thirty-six miles—the Spoon, the Sangamon and Crooked creek—or nearly sixty per cent of the area below LaSalle-Peru. The lower division receives but 11.1 per cent of the drainage, in more than one-third the length of the river, and the largest tributary, Macoupin creek, drains less than one thousand miles.

Detritus from the upper basin has made bottoms and defines the stream-bed, but has not been sufficient to obliterate the remnant of the old stream-bed, Lake Peoria. Local drainage from Peoria to Pekin has given a narrow stream-bed, and bottoms unusually well built up. The central basin has filled in very extensive bottom lands opposite and below the large tributaries, while in the lower division extensive bayou and lagoon development is left between the several minor tributaries.

These conditions affect the low water distribution and the flood regimen. The upper basin and the central basin are frequently not in the same storm track. A headwater flood fills the bottoms from above and lessens in height down stream, while a central basin flood has been known to run up stream over the dam at Copperas creek. Flood conditions are also greatly influenced by the stage of water in the Missis-

issippi at Grafton, coincidence in time of high water being the exception rather than the rule. Floods have been recorded in the Mississippi river at Grafton higher in elevation than the original low water plane at Utica.

Physical Elements—Lower Illinois River.

LOCALITY.	Distance—miles...	Low water width—feet.....	BELOW CHI-CAGO DATUM.			BANK HEIGHT—FEET.		Remarks.
			LOW WATER		High water 1904.....	Av.	Range.	
			Natural...	Dams.				
Utica bridge.....	0.0	0 0	147.0	142.6	120.8	.....	.....	.....
Illinois and Michigan canal..	6.5	536	147.8	143.4	122.3	10.4	8-13	LaSalle-Peru.....
Hennepin canal.....	19.4	696	149.2	143.6	124.7	11.0	8-15	Above Hennepin..
Henry dam.....	33.5	754	150.3	143.7	126.0	9.4	9-11	Crest of dam, 143.9..
(Opened Oct., 1871).....	.....	.....	.....	147.8	.....	.....	.....	Below dam.....
Chillicothe.....	47.9	738	150.8	147.9	126.7	11.4	7-15	Railway bridge.....
Peoria.....	67.3	1,698	151.2	148.2	128.1	7.1	4-12	Wagon & Ry. bridge
Pekin.....	76.6	604	152.4	148.2	131.8	11.0	4-15	Railway bridge.....
Copperas Creek dam.....	92.8	653	154.2	148.3	133.6	13.7	12-15	Crest of dam, 148.0..
(Completed Oct., 1877).....	.....	.....	.....	152.8	.....	.....	.....	Below dam.....
Havana.....	109.9	603	155.1	153.1	135.4	10.0	7-12	Bridge.....
Sangamon river.....	129.8	636	158.4	153.6	138.3	11.0	9-12	Two miles above...
Beardstown.....	141.3	679	160.0	153.8	139.9	11.5	10-13	Wagon bridge.....
LaGrange dam.....	152.1	732	161.8	154.0	141.4	11.4	8-15	Crest of dam, 154.4..
(Opened Oct., 1889).....	.....	.....	.....	162.0	.....	.....	.....	Below dam.....
Wabash Ry.....	168.1	783	165.4	162.8	144.3	11.5	7-15	Valley City.....
Alton Ry.....	186.6	835	167.4	162.8	148.0	11.8	8-15	Pearl.....
Kampsville dam.....	198.1	910	171.0	163.1	149.6	11.8	8-15	Crest of dam, 163.2..
(Opened Sept., 1893).....	.....	.....	.....	171.6	.....	.....	.....	Below dam.....
Hardin.....	208.4	979	172.4	172.8	150.5	13.5	9-16	.....
Mouth.....	227.5	1,040	174.1	175.0	151.8	11.5	9-15	Illinois river.....
Grafton.....	229.6	.....	174.4	175.3	152.0	.....	.....	Mississippi river...

Natural low water—Henry pool, 1871; Copperas creek pool, 1873; below Copperas creek, 1879.
Low water with dams—Henry pool, 1879; Henry to mouth, 1894.
Average widths prior to erection of dams—Surveys of 1867 and 1879; also bank high.
Distance and elevations by latest surveys (1902-5).
The water area of the river on the recent maps average one-fifth (1,056 feet) miles in width.

The accompanying table gives the length of characteristic reaches, low water widths and the bank height prior to the erection of the dams, and the low water elevation before and after the building of the dams and the high water elevation of 1904. The channel depth and cross sections are omitted, as the normal low water plane of reference has been changed by the pool level formed by the dams.

An inspection of the channel profiles of the recent surveys in connection with the old low water, shows marked changes in the bed of the Henry and Copperas creek pools, the bars in some cases having risen above the low water plane prior to the erection of the dams. This would indicate that the tributaries have filled in their beds across the bottoms and are now dumping their loads in the river bed, and similar results are to be expected in due season in the LaGrange and Kampsville pools. In other words, the effect of the slack water improvements, so-called, is to raise the horizon of the river bed and eventually the river itself with respect to the bottom lands.

The Illinois River Bottoms.

County.	Distance from Utica bridge—Miles.....	Water Illinois River —Acres.....	Area ponds, etc— Acres	Total—Acres	Land under H. W. 1904—Acres	Total land and water under H. W. of 1904 —Acres	Approximate from H. W. of 1904 to 15 feet above—Acres.
LaSalle	9.3	606.8	201.0	807.8	4,910.8	5,718.6	1,195
Bureau	23.7	652.5	1,231.5	1,884.0	8,071.9	9,955.9	833
Putnam	34.1	2,214.0	5,776.0	7,990.0	10,519.1	18,509.1	1,499
Marshall	48.5	1,444.8	1,585.4	3,030.2	10,080.3	13,110.5	9,063
Woodford.....	61.8	2,969.6	744.5	3,714.1	8,224.1	11,938.2	1,834
Peoria.....	90.2	5,105.9	855.3	5,961.2	13,282.4	19,243.6	4,264
Tazewell.....	96.4	2,120.4	4,054.0	6,174.4	17,761.8	23,936.2	7,957
Fulton	120.9	1,372.5	8,221.9	9,594.4	32,618.2	42,212.6	7,340
Mason.....	131.6	1,026.2	6,390.7	7,416.9	22,048.9	29,465.8	4,974
Schuyler.....	145.7	1,065.9	1,924.7	2,990.6	17,615.3	20,605.9	3,633
Cass.....	154.8	1,156.6	6,487.1	7,643.7	29,931.3	37,575.0	11,363
Brown.....	157.5	550.2	937.0	1,487.2	7,695.6	9,182.8	1,394
Morgan	161.6	320.2	548.0	868.2	3,949.6	4,817.8	13,214
Scott.....	181.6	1,081.6	3,341.5	4,423.1	28,413.3	32,836.4	12,204
Pike.....	190.9	1,901.9	1,369.6	3,271.5	14,140.4	17,411.9	4,592
Greene.....	210.9	1,964.8	3,879.4	5,844.2	34,845.4	40,689.6	5,224
Jersey.....	227.7	952.5	1,120.8	2,073.3	10,760.0	12,833.3	1,695
Calhoun.....	227.7	2,305.0	736.1	3,041.1	10,785.1	13,826.2	3,187
Total—acres.....	.....	28,811.4	49,404.5	78,215.9	285,653.5	363,869.4	95,465
Total—square miles.....	.....	45.02	77.19	122.21	446.33	568.54	149.16

NOTE—The area of the islands is included in the column “Land under High Water of 1904,” and contains 4,134.9 acres.

The accompanying table has been carefully worked up from the detailed charts of the recent survey. The total area under the high water of 1904 is 568.54 square miles (363,869 acres), of which 446.33 square miles (285,654 acres) is land lying above the present low water as formed by the dams. The water area is 122.21 square miles (78,216 acres), of which sixty per cent lie outside the main river bed. The flood of 1904 was perhaps the most uniform in character throughout the Lower Illinois, except that the Mississippi was at relatively lower stage, and it was only exceeded as a whole by the floods of 1844 and 1858.

The approximate area of land between the flood line of 1904 and a level fifteen feet above, is 149.2 square miles (95,465 acres.) Perhaps two-thirds of this was reached by the flood of 1844. The limits are in most cases the foot of bluff slopes, giving a total area of valley of 717 square miles.

About twenty-eight per cent of the overflow area (1904) lies opposite the Henry and Copperas creek pools (93 miles) and is dominated by the Upper Illinois, about thirty-six per cent opposite the LaGrange pool (59 miles) and dominated by the Central basin, and thirty-six per cent below LaGrange dam (76 miles) and dominated by the Central basin, and perhaps still more by back water from the Mississippi. The reservoir effects of the bottoms diminish flood heights down stream until they reach the minimum between Havana and Beardstown and opposite the great Sangamon bottoms, thence flood range increases in the approach to the Mississippi.

The water areas outside the river bed are greater than they would be at normal low water in the absence of the dams, so the estimate is a fair measure of the lands subject to reclamation provided the low water plane shall not be raised an equivalent amount after the removal of the dams.

The two greatest floods of record (1844 and 1858 not available) at LaSalle-Peru, were identical in height, 1892 and 1904, and in relation to the known volume of 1892 at Morris, the volume is estimated at 93,600 second feet. The ordinary extreme occurring once or twice in a decade may be taken at 60,000 to 67,000 second feet. The normal equivalent for the mouth should be 166,000 second feet or about 75 per cent more than at LaSalle-Peru.

As a matter of fact, except when the Illinois is high in relation to the Mississippi, as in 1904, the flood volume at the mouth for a general flood is less rather than greater than at LaSalle-Peru. The measured flood of 1904 at Pearl reached a limit of 117,000 second feet and was estimated 115,000 for Beardstown, 100,000 for Havana and 90,000 for Peoria, the estimates to be taken with caution. A consideration of the storage effects of the bottoms, the prolongation of the rise and the capacity of the river channel, justifies such a condition of fact.

For every day the river is out of banks at Morris (above ten feet) it will be out of banks (above twelve feet) for six or eight days from Peru to Copperas creek and 20 per cent longer at LaGrange, the period increasing down stream under the effects of the Mississippi.

The bank-full capacity of the river (twelve feet above normal low water) under conditions of steady flow, may be taken at about 20,000 second-feet down to Copperas creek, increasing to 30,000 feet at LaGrange and to 40,000 feet at Kampsville. Such capacities in comparison with the proper flood volume indicates extreme overflow and greatly prolonged durations. By reason of the slight declivity and the lack of co-incidence in the flood periods in the upper basin, the central basin and in the Mississippi, the working out of the normal relation of volume to stage is most difficult.

The flood of 1892 is the greatest in volume known for the Upper Illinois. Its height at LaSalle-Peru was identical with that of 1904, dropping gradually to about two feet below opposite the broad bottoms of the LaGrange pool between Havana and Beardstown, thence rising above 1904 about fifty miles above the mouth under the influence of the Mississippi. The high water of 1883 rose to extraordinary heights from ice gorges in the Upper Illinois, but was about a foot lower than 1904 from Peru to Hennepin, and two feet from Henry to Peoria, rising to two feet above opposite the central basin—Sangamon river to Beardstown—thence dropping to a foot below at the mouth. The great flood of 1844 was six feet above 1904 in the Peoria-Pekin reach, dropping to a limit of two to 2.5 feet above, opposite the great bottoms between Havana and Beardstown, thence gradually rising to 8.6 feet above at the mouth. The flood of 1883 shows the effect of conditions from the central basin, and 1844 the effect of the wide bottoms and of the Mississippi.

The large water areas in the Illinois bottoms feed the low stages of the river and greatly reduce the period of low water. In a period of eleven years, the river at Copperas creek was less than two feet above low water for an average of forty-two days, and at LaGrange for sixty-two days, and these points may be taken as a measure of the upper and lower halves of the river. When the water areas are drained out, a low water period ensues, but not in every year. LaSalle had a measured discharge of 633 second-feet prior to 1867, and lower estimates for Henry and Copperas creek have been made for later dates. Measurements in the lower division, in 1879 and 1887, gave from 1,500 to 1,700 second-feet, part of which was canal water from Lake Michigan. A standard of 600 second-feet for the upper division, and of 1,200 feet for the lower division may be taken for the minimum natural flow.

No sufficient study has been made of the average run-off for the Illinois basin. Judging by the Upper Mississippi on the west and the lakes basin on the east, it may be taken at three-fourths second-feet per square mile, or about half the bank-full capacity for the several divisions of the stream. The minimum flow is only six per cent of this average, which is certainly very remarkable. This indicates that the basin has a tight or impermeable sub-soil, and that the waters reach the drainage lines substantially by surface flow. When the surface soil is dried out and ponds and marshes exhausted, extreme low water occurs.

Doubts might be raised as to the ability of the Lower Illinois, with its peculiar regimen, to maintain indefinitely the integrity of its channel under the increasing loads of detritus due to the cultivation of lands and reclamation of marshes. Whatever opinion may be in this regard, there can be no doubt as to the injurious tendencies of the four dams, the two State dams at Henry and Copperas Creek, and the two United States dams at LaGrange and Kampsville. The two State works have been in operation for over thirty years, and the channel capacity in the pools is certainly diminishing, results that will show up in the other two pools in due season. An open river with an augmented flow within the banks will certainly reverse present tendencies in a desirable direction.

The Illinois river drains a basin rich in surface soils and luxuriant with verdure in the growing season. Its waters are naturally highly charged with organic matter, well fertilized in fact, and thus are nurtured the many forms of life which constitute fish food. The Illinois river was in nature well stocked with fish, but in the long and hard winters the organic matters exhausted the oxygen beneath the ice cover, and the fish asphyxiated. In low water periods the river was ill suited to receive any considerable addition to its organic load. The waters of Lake Michigan are charged to the limit with oxygen, and can therefore receive a much larger load of organic matter than river waters from fertile basins. If the dilution is sufficient to maintain a surplus of oxygen at the outset the increment of flow has become purer, chemically and biologically, by the time it reaches the Lower Illinois, than any of its natural tributaries. The augmented volume at low water and under the ice, is a radical change in condition for the better.

The fish crop of the Lower Illinois river has more than doubled since 1889, and now amounts to over 22,000,000 pounds, with a value of more than three-quarters of a million dollars on the banks (doubled to consumers.) This amounts to \$10.00 per acre for all the lands under water in the valley, and is 80 per cent of the value per acre of farm crops in Illinois. This crop will no doubt increase further with improved water conditions: It may not be too much to say that the most economic example of sewage disposal in the world is that by means of the sanitary and ship canal of Chicago, augmenting the water volume and fertilizing the fish reserves of the Illinois valley.

Aside from their value for reclamation and cultivation, the bottom lands of the Illinois have an intrinsic value as a forest reserve, the low land timber being in demand for many uses. The reclamation of many areas has been undertaken by levees along river front and up tributaries to the bluffs, and by keeping down the interior water during high stages by means of pumping works. Every year shows an increased use of the bottom lands, and the opinion of Captain Howard Stansbury in 1838 may be embalmed as a literary curiosity along with Proctor Knott's speech on Duluth.

10. THE TRIBUTARY DIVISION.

Within this division the great tributaries unite—the Missouri, the Upper Mississippi and the Illinois—to form the Middle Mississippi. The Missouri coming remotely from the Rocky Mountains, has a basin area of 530,810 square miles. The portion east of the semi-arid region has about the same area as the Upper Mississippi, including the Illinois, but not over 20 per cent of this portion is equal in water yield. The Upper Mississippi has an area of 143,660 square miles, and the Illinois 27,910, a total of 171,570 square miles at the junction with the Missouri. The Middle Mississippi drains 18,010 square miles, and the total above Cairo is 720,390 square miles.

The Missouri, like all streams from semi-arid regions, is subject at rare intervals to extraordinary floods, double in volume those from the Upper Mississippi, but its low water volume is less, and may be taken at 26,000 second-feet as compared to 30,000 second-feet from the Upper Mississippi, including the Illinois. The total is 56,000 second-feet, which is taken as standard low water at St. Louis, and is equivalent to four feet on the gauge. Extreme low waters of 40,000 second feet, and even 35,000, have occurred at St. Louis, but these minimums are abnormal and usually the result of ice effects. The recent report takes the low water volume of the Upper Mississippi at 25,000 second feet, and the same for the Missouri, a total of 50,000 feet.

The distance from Grafton, 2.1 miles below the mouth of the Illinois river, to the Eads bridge at St. Louis, may be taken at forty miles, and the declivity at very low water at twenty-four feet.

The distance and falls are distributed as follows:

Locality.	Distance in miles.	Fall in Feet.
Grafton.....	0.0	0.0
Alton (dam below railway bridge)	15.5	8.4
Missouri river (mouth of).....	7.5	6.2
Merchants' bridge	14.0	9.3
St. Louis (Eads Bridge).....	3.0	0.1
Total	40.0	24.0

Beginning three miles below Alton, the slope is pronounced for three miles; and again, in the seven miles above the Merchants' Bridge, exceeding a foot per mile.. The river is fixed and deep opposite St. Louis, and the pool level of the recent report is taken at 199 feet below Chicago datum. The river in the vicinity of the mouth of the Missouri is unstable, and its regimen very complex, but it need not be discussed at this time, in view of the proposed canal some eighteen miles long from below the Alton railway bridge to St. Louis harbor at a point 0.85 miles above the Merchants' Bridge.

The Grafton-Alton reach, 15.5 miles long, averages 3,500 feet in width, with a bank height of 16.5 feet, and five feet above this level overflow becomes widespread. The river averages thirty-seven days out of bank. The high water of 1903 at Grafton was 27.6 feet above low water as used in the report, or 4.5 feet above that of 1904 (height rapidly diminished up the Illinois) and was measured at 365,573 second-feet. This does not represent the extreme volume from the Upper Mississippi, but the height reached was extraordinary and due in part to the great high water in the Missouri. The height given for Alton was 33.1 feet, and above the Merchants' Bridge at 41.0 feet. It will be noted that the absolute elevation of the flood at St. Louis was seventeen feet above low water at the mouth of the Illinois, and within eleven feet of the original low water plane at Utica.

The natural bar depths at low water were about thirty inches, and the adopted project for the Upper Mississippi contemplates a minimum of six feet. The proposed dam at Alton makes much greater depth practicable.

The volume equivalent to one foot on the guage at and near low water for Grafton is 8,213 second-feet, and at St. Louis 10,000 second-feet. An increment of 14,000 second-feet at low water is equivalent to a stage of 1.7 feet at Grafton and 1.4 feet at St. Louis.

The Upper Mississippi hugs the bluff line to Alton, and the contribution of detritus from the Illinois has been insufficient to swerve it from its course. The Missouri runs near the southern bluff, touching it occasionally. Between the two rivers, from St. Charles to Alton, is a very extensive bottom, built up largely by deposits from the Missouri, and these are the richest farming lands in Missouri.

11. THE MIDDLE MISSISSIPPI.

The Middle Mississippi extends from the Eads Bridge at St. Louis 186 miles to Cairo Point, where it joins with the Ohio (205,750 square miles) to form the Lower Mississippi. The total descent at low water is 107.7 feet, an average of 0.58 feet per mile. The valley is of moderate width, bold and deeply cut, and practically terminates at Cape Girardeau, fifty-one miles by river above Cairo, and the true head of the alluvial valley or delta region. Seven miles below Cape Girardeau the river passes for seven miles through a rock gorge or canon between Gray's Point and Commerce, a rock-bound river bed, similar to the pass at the Des Moines Rapids and above Rock Island, on the Upper Mississippi, and all rock disappears at thirty-seven miles above Cairo. The most considerable tributaries are the Kaskaskia and the Big Muddy, both from Illinois, but the drainage is small; the river, in fact, being an intermediate link between the northern basin of the Missouri and Upper Mississippi and that of the Ohio. The river bed is unstable and inherits its character from the Missouri. The slope is high and unevenly distributed and rock intrudes into the channel in localities. The following table exhibits distances and grades:

St. Louis to Cairo—Distances and Elevations.

Locality.	Distance— miles.	Below Chica- go datum.	Above sea level.	Remarks.
Eads bridge.....	0.0	195.9	383.0	4 feet on gauge.....
Meramec river.....	20.0	*205.0	373.9	Approximate.....
Rush Tower.....	39.0	212.8	366.1	.....
White Sand depot.....	54.0	222.8	356.1	.....
Chester.....	75.0	236.7	342.2	.....
Grand Tower.....	105.5	*255.0	323.9	Approximate.....
Bainbridge Landing.....	124.0	263.8	315.1	.....
Grays Point.....	142.0	272.8	306.1	.....
Commerce.....	149.0	*278.0	300.9	Approximate.....
Cairo Point.....	186.0	303.6	275.3	Ohio river.....

*Reduced from charts of Mississippi River Commission. Stage is equivalent to 4 feet on St. Louis gauge, and corresponds to 56,000 second-feet.

The normal flood volume is taken at 550,000 second-feet, but at long intervals floods of 750,000 to 1,000,000 feet occur. Standard low water is taken at 56,000 second-feet and at four feet on the St. Louis gauge, which fairly indicates the regimen down to Grays Point, thence to Cairo the river is dominated by back water from the Lower Mississippi.

The natural low water depth on bars may be as little as four feet, and even less in localities. A project for regularization had been adopted on the basis of eight feet minimum depth, and work had extended from St. Louis to the vicinity of St. Genevieve, but appropriations have been discontinued.

The minimum depths do not represent the available boating conditions, but rather the season when traffic is discontinued except by the smaller craft. A consideration of the available stages is therefore important.

Mr. John A. Ockerson, member of the Mississippi River Commission, and a Commissioner of the Louisiana Purchase Exposition, prepared a chart in the interest of direct shipment of foreign exhibits to St. Louis, showing the navigable condition of the Mississippi river for the four months, March, April, May and June, for the period of twelve years, 1892-1903, inclusive, during which occurred the extraordinary drought period that culminated in 1895. This chart recognizes the well known phenomena of bar rise in broad reaches, which varies in different years through a range of 5.5 feet. The highest bar level is taken for each four months period, which errs toward conservatism, as bar levels change from time to time.

As July is equally favorable with June and August with March, these two months are added to complete the regular high water season.

Navigable Depth of Less than Twelve Feet, 1892-1903—Twelve Years.

Month.	Number of days.	Average per year.
March	180	15
April	144	12
May	114	9.5
June	84	7.0
July	84	7.0 est
August	180	15.0 est
Yearly average		65.5
Period of more than 12 feet		118.5 days
Estimate by inspection for remainder of year		31.5 days
Probable average time of 12 feet of water		150.0 days

Under date of November 8, 1904, Mr. Ockerson says: "From St. Louis to Cairo depths of from eight to ten feet may be counted on for at least half of the year on the average. These latter conditions grow naturally better as the improvement work progresses."

The standard steamboat and barge, formerly in the St. Louis trade, carried from nine to eleven feet, and the two great steamboats, the Jim Howard and the Grand Republic, carried twelve to fourteen feet. Such depth continued long enough to be commercially availed of.

Any improvement of the stream presumes fixed banks and a uniform width or "regularization," and the adopted project was to produce eight feet at standard low water. When the stream dissipates in broad reaches the phenomena of bar rise and variable channels are pronounced. The chief purpose of regularization is to restrict these variations within moderate limits and below a definite horizon. Under such conditions the inferences from the stages of water are important. The following table gives the duration of stages of three, four and five feet above standard low water:

Duration of Stages of Water at St. Louis; Days—1870-89.

(Above standard low water, or four feet on gauge.)

	3 feet.	4 feet.	5 feet.
January	22.5	20.5	15.5
February.....	23.3	20.2	17.4
March	29.9	23.6	26.8
April.....	30.0	30.0	30.0
May.....	31.0	31.0	30.5
June	30.0	30.0	30.0
July.....	31.0	31.0	30.5
August.....	29.1	26.1	23.5
September.....	22.8	19.2	14.8
October.....	21.7	17.2	13.4
November.....	19.6	17.7	14.2
December	13.1	10.5	8.4
Total.....	304	282	255
Variation	206 to 365	180 to 356	156 to 348
Continuous	178	174	170
Average	Mar. 2-Aug. 29	Mar. 3-Aug. 26	Mar. 5-Aug. 23

The five-foot stage was continuous throughout the twenty years for the four months of April, May, June and July, except in 1871 and 1889, and was short nine years each in March and August and continued for five years in September. The four-foot stage was short seven years each in March and August and continued for eight years in September. The three-foot stage was short five years in March and August and continued for eleven years in September.

If the bar horizon is restricted to a depth of eight feet below standard low water, then eleven feet will prevail for 304 days of the average year; twelve feet for 282 days and thirteen feet for 255 days.

Whatever may be the effect of regularization, it is a condition precedent to any treatment, and it cannot develop its full utility until the high water areas are so built up as to make high and low water follow substantially the same track. It is now recognized that the results of such treatment are limited without producing material changes in slope and a lowering of the low water plane. The depth obtainable by regularization may be increased in three ways:

- 1. By subdividing the pools by means of ground sills, thus dividing bar slopes and reducing the bar horizon.
- 2. By taking out the excess of slope by an occasional lock and dam, leaving only such fall as is required for an economical channel.
- 3. By increasing the low water volume, and this method will be considered further.

We may adde 50 per cent to the standard low water volume of the Middle Mississippi, 25 per cent or 14,000 second-feet through the works already provided at Chicago and a second 14,000 feet by means of reservoirs at headwaters. The equivalent for one foot at and near low water is 10,000 second-feet, and the effect of 28,000 second-feet will be 2.8 feet if it represents solely increase in stage. With eight feet by regularization, this means 10.8 feet minimum, 13.8 feet for 304 days, 14.8 for 282 days and 15.8 for 255 days.

The probable effect will be to lower the bar horizon rather than raise the stage, and this will be proportionate to the added volume, or 50 per cent (four feet) to the eight feet obtained by regularization. This means 12 feet minimum, 15 feet for 304 days, 16 feet for 282 days and 17 feet for 255 days. The effect of 25 per cent, or the 14,000 second-feet from Chicago, will be two feet of added depth, or 10 feet minimum, 13 feet for 304 days, 14 feet for 282 days and 15 feet for 255 days.

It is a truism that the more uniform the volume the more regular is the channel. Streams that have great variation in volume have a small low water flow in a great stream bed fashioned for high water conditions. Normal flood is ten times normal low water in the Middle Mississippi. Adding 50 per cent to low water reduces this ratio to 7 1-3, which in itself is a great betterment in conditions.

12. THE LOWER MISSISSIPPI.

The Lower Mississippi extends through an alluvial plain of over 30,000 square miles, with an occasional bluff contact on the east, from the junction with the Ohio to the Gulf of Mexico. Its length is 1,072 miles, or 764 miles to Red river, which is virtually at the head of deep water. The declivity from standard low water at Cairo is 275.3 feet, and this may be taken to Red river, below which the low water slope is nominal. The normal width is about 3,300 feet above Red river, except where the river is spread out, but it narrows and deepens on the low grades below Red river.

The basin at Cairo is 926,140 square miles. It adds the Arkansas, 200,820 square miles; and the Red, 99,200 square miles; and the local drainage is 33,220 square miles, a total of 333,240 square miles, a part of which is from the semi-arid region. The grand total is 1,259,380 square miles.

The normal flood volume at Cairo is 1,100,000 second-feet, but this may occasionally reach 2,000,000 feet. Owing to wide overflows into the St. Francis and the Yazoo and the Tensas basins, these floods were retarded and prolonged and reduced in volume, and reduced also by outlets below Red river, so that the volume passing New Orleans (107 miles from the gulf) in extreme flood was greatly reduced below that at Cairo. The policy of reclamation now under way restrains flood waters to the river channel and is a material change in natural conditions.

The river course exceeds the direct distance by over 60 per cent, or there is a great development in loops and bends, especially between Memphis and Red river, where the development is about 90 per cent. The aggregate length of the cut-offs in this portion of the river have been about one-third during the historic period, and this appears to have been recovered, or the shortening was but temporary.

The standard low water volume for the river from Cairo to the Arkansas is taken at 121,000 second-feet, and from Arkansas river to Red river at 132,000 second feet. The equivalent of one foot on the gauge at and near low water varies from 18,000 to 20,000 second feet.

Before works were undertaken forty-three localities were recognized below Cairo where depths were liable to be less than ten feet, not in

every year nor all in any one year. Of these, twenty-two places were liable to depths less than seven feet; and of these again, thirteen to depths less than five feet. The project for a minimum of ten feet proceeded on the theory that these localities could be corrected without disturbing the general regimen of the river, in view of the fact that the irregularities of profile were only at low water, while the high water line was normal, so the dynamic situation at high water need not be disturbed. Some reaches were attempted with beneficial results, but the works have not continued.

Meantime large appropriations have been made in coöperation with the states for the development of a levee system which will confine all the water to the river channel. The dynamic effect is yet to be valued, but whatever it may be, the reclamation of lands is to be conceded and the improvement is subject thereto as a condition precedent. The reclamation has proceeded so far that the levee advocates are coming to recognize the necessity of holding the eroding banks as a question of levee maintenance, and the policy of fixation of river course will be the necessary sequel.

As to the available depths in the natural river, Mr. Ockerson may be again quoted: "For an average of seven or more months of each year a depth of at least twelve feet can be relied upon from Cairo down. During the balance of the season dredges will maintain depths of eight feet or more."

Hydraulic dredges for making low water channels across the bars have come into practice within the last twelve years, and experience has fully demonstrated their efficacy. It is found that these cuts often lead the high water course and produce changes that persist and are permanently beneficial, so that they become useful as an auxiliary in a permanent improvement while serving their primary purpose for channel maintenance.

The following table gives the duration of stages above standard low water:

Item.	5 feet.	8 feet.	10 feet.
Total days.....	283	243	218
Days continuous.....	268	215	180
Dates between (continuous)	Dec. 13 to Sept 6	Jan. 5 to Aug. 7	Jan. 20 to July 18

Assuming that special treatment at localities restricts the bar horizon at or below a depth of ten feet at standard low water, then the following depths will be available: Fifteen feet for a total of 283 days, 18 feet for 243 days and 20 feet for 218 days.

The increment of 28,000 second-feet (23 per cent) from the lakes and from the Upper Mississippi will give an additional depth of 1.5 to 2.3 feet, according as the effect is due to stage or lowering of the bar horizon. One-half of these results will be due to an increment of 14,000 second-feet from the lakes.

From the foregoing it is safe to say that with an increment to low water and the aid of hydraulic dredging a navigable depth of fourteen feet can be maintained throughout the average year, and that greater

depths will be available for a part of each season. It is safe to say further that with the correction of the worst localities, these greater depths will give a navigable season longer than now exists in the great lakes.

13. RESUME.

The following table gives elevations and distances, Lake Michigan to the Gulf of Mexico:

Division.	Locality.	Distance— miles.	ELEVATION—FEET.	
			Below Chicago datum.	Above sea level.
The Chicago Divide, (41.3 miles).....	Lake Michigan.....	0.0	0.0	578.91
	End of Canal.....	36.05	6.6	572.3
	Lake Joliet.....	41.3	76.5	502.4
The Upper Illinois, (56.2 miles).....	Ottawa.....	86.4	132.2	446.7
	Utica Bridge	97.5	147.0	431.9
The Lower Illinois, (227.5 miles).....	Peoria	164.8	151.2	427.7
	Beardstown	238.5	160.0	418.9
	Grafton	327.0	175.0	403.9
The Tributary Division, (42.1 miles).....	Alton	342.5	189.5	389.4
	St. Louis.....	367.0	195.9	383.0
The Middle Mississipi, (186 miles).....	Grays Point.....	509.0	272.8	306.1
	Cairo Point.....	553.0	303.6	275.3
The Lower Mississipi, (1072 miles).....	Memphis.....	783.0	.....	.....
	Arkansas river.....	995.0	.....	.....
	Red river	1,217.0	.....	.....
	New Orleans.....	1,518.0	.....	.....
	Gulf of Mexico.....	1,625.0	578.91	0.0

Distance shortened by Canal—Alton to St. Louis—2.5 miles.

With the Middle Mississippi regularized and an increment of 14,000 second-feet to the low water volume, it will be feasible to carry a depth of fourteen feet from St. Louis to the Gulf of Mexico for a period longer than the period of navigation about the great lakes, and hydraulic dredging can maintain the depths for the remainder of the year. By increasing the water supply and by correcting the worst localities on the Lower Mississippi, the fourteen foot period, without dredging, can be materially prolonged and eighteen feet made available for more than half the year. It is sufficient at this time to indicate the possibilities, without entering into an exhaustive discussion of the Middle and Lower Mississippi, in order that the waterway between Lake Michigan and the Middle Mississippi river may be projected on a proper basis for future development.

The route from Chicago to St. Louis may be made of any desired capacity, being solely a matter of water supply and the resources that shall be made available.

Part III. The Deep Waterway.

(Chicago-St. Louis.)

14. THE FEDERAL PROJECT.

The River and Harbor Act, approved June 13, 1902, appropriated the sum of \$200,000.00 "for making such surveys, examinations and investigations as may be required to determine the feasibility of and prepare and report plans and estimate of cost of a navigable waterway fourteen feet in depth from Lockport, Ill. * * * St. Louis, Mo.," the Mississippi River Commission to direct the expenditure of \$25,000.00 and report upon the division from the mouth of the Illinois river to St. Louis, and a board of three army engineers to direct the expenditure of the balance and report upon the division from Lockport to the mouth of the Illinois. The report of the Mississippi River Commission was submitted February 28, 1905, and of the Board of Engineers, August 25, 1905, Colonel O. H. Ernst (now Brigadier General retired) chairman in each case.

An elaborate survey, covering the bottom lands within the bluffs, was made of the Lower Illinois river. Former surveys were built upon for the Upper Illinois and Desplaines rivers. The charts of the Mississippi River Commission were availed of below the Illinois and only special examinations were made. A line of triangulation and precise levels were carried throughtout and many flow measurements were made. The borings were very complete. All accessible gauge records, flood heights and flow measurements were completed and constitute a valuable compendium for reference.

The project is for a depth of fourteen feet, with a flow of 10,000 second-feet from Lake Michigan. The estimate is:

Lockport to mouth of the Illinois	\$23,543,582 00
Mouth of Illinois to St. Louis	6,553,880 00

Lockport to St. Louis	\$30,097,462 00
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The locks estimated are 600 feet long by eighty feet wide (641 feet long between hollow quoins.) Locks for a depth of twenty feet between Lockport and Utica are estimated at \$1,376,000.00 additional.

The following table gives the elements of the project for the Desplaines and Upper Illinois between the end of the sanitary and ship canal at Lockport and the Lower Illinois river at Utica.

Elements of the Project—Lockport to Utica.

LOCATION.	DIST- ANCE MILES.	SURFACE OF WATER OF PROJECT BELOW CHICAGO DATUM.		LOCKS— ELEVATION.			
		River.	Canal.	No.	Upper Miter Sill.	Lower Miter Sill.	Lift.
Drainage canal control- ing works (†)	0						
Begining of project.....	2.09	.....	3.00	1	17	56	39
			42.00				
Dam No. 1, Joliet	4.69	.....	42.00	2	56	66	10
			†52.00				
Head Lake Joliet.....	7.79	.....	52.00	3	66	86	20
			72.00				
Foot of Treats Island....	13.99	.....	72.00	4	86	96	10
			82.00				
1½ miles below Kankakee river.....	21.49	.....	82.00	5	96	107	11
			93.00				
	22.36	92.7					
	27.21	93.5					
	33.48	94.8					
	38.52	95.3					
	41.40	95.7					
Marseilles.....	45.74		96.00	6	110	100	G'rd
Middle of Bell's Island..	48.78		96.00	7	110	129	19
			115.00				
Head of Bull's Island ...	52.00		115.00	8a	129	137	8
			123.00				
Lover's Leap	62.03		123.00	10a	137	150	13
Utica.....	63.53		136.00				

The width of the canal is 160 feet on the bottom.
The width of the channel is 200 feet on the bottom, with side slopes of 3 to 1.
The size of the locks are 600 feet long by 80 feet wide.
†The zero of distance is 34.05 miles from Lake Michigan at mouth of Chicago river.

The following table gives the elements of the project for the Lower Illinois and between Grafton and St. Louis. A column is added to show the proposed surface of the water in the fourteen foot channel above original low water:

Elements of the Project—Utica to St. Louis.

LOCATION.	DISTANCE MILES.	LOW WATER SURFACE OF PROJECT.		REMARKS.
		River (Below C. D.).	Above Standard Low Water.	
Utica	63.53	135.8	11.00	.....
Peru	71.42	137.8	10.10	.....
Henry	97.31	141.1	9.35	.....
Santa Fé Bridge.....	111.02	142.3	8.43	.....
Spring Bay.....	118.39	142.6	8.33	.....
Peoria	132.25	143.0	8.42	.....
Pekin	140.96	144.2	8.28	.....
Head of Senate Island....	157.73	146.6	7.66	.....
Liverpool	164.60	147.5	7.20	.....
Havana.....	173.05	149.4	5.80	.....
Foot of Grand Island.....	186.36	151.5	5.83	.....
Beardstown	203.35	154.5	5.40	.....
Meredosia.....	222.19	158.4	4.40	.....
Head of Big Blue Island..	234.01	160.3	4.30	.....
Pearl.....	250.03	163.3	4.04	.....
Kampsville	261.81	167.0	4.02	.....
Grafton	293.09	168.3	5.82	.....
Alton dam.....	308.59	169.0	14.50	Canal, 18 miles long.
*St. Louis	326.59	169.0	30.00	Canal ends.....
Merchants' Bridge.....	327.44	199.0	0.00	.....

The width of the channel is 200 feet on the bottom, with side slopes of 3 to 1. Canal is 160 feet wide on the bottom, with side slopes of 2 to 1.
Zero of distance is 34.05 from Lake Michigan at mouth of Chicago river.
*30 foot lift lock, the elevation of upper miter sill being 183, and the lower miter sill being 213 below Chicago datum.

The following table exhibits quantities and cost for characteristic reaches between Lockport and St. Louis:

Estimate of cost of Fourteen-foot Waterway from Lockport to St. Louis.

Division.	Items.	Quantities.	Price per unit.	Cost.	Total cost.
Lockport to dam No. 1, Joliet, 2.6 miles.....	Excavation, rock, cubic yards.....	186,230	\$3 00	\$ 558 690	\$2,089 537
	Lock No. 1, 39-foot lift			1,185 958	
	Rebuilding bridges, 1 railway, 2 highway			154 931	
	Contingencies, 10%.....			189 958	
Canal dam No. 1, Joliet to head of Lake Joliet, 31 miles	Excavation, rock, cubic yards.....	240,118	1 00	\$ 240 118	3,374 539
	Excavation, earth, cubic yards.....	248,160	25	71 040	
	Excavation, widening river, rock, cubic yards	124,811	1 00	124 811	
	Excavation, widening river, earth, cubic yards.....	152,995	25	38,249	
	Embankment for canal, cubic yards....	221,508	25	55,377	
	Locks No. 2, 10-ft lift; No. 3, 20-ft. lift.....			1,156 069	
	Rebuilding bridges, 1 railway, 5 highway			642,532	
	Right of way, widening river.....			424,897	
	Right of way, canal acres	89	150 00	13,350	
	Concrete betw'n river and river, cubic yards.....	50,220	6 00	301,320	
	Contingencies, 10%.....			306,776	
Head of Lake Joliet to foot of Treat's Island, 6.2 miles.	Excavation, rock, cubic yards.....	15,911	3 00	\$ 47,773	1,078 526
	Excavation, earth, cubic yards	1,138,972	25	284,743	
	Lock No. 4, 10-foot lift			481,179	
	Dam No. 2			62,963	
	Bridges, 1 highway ..			70,060	
	Land to be overflowed			33,880	
	Contingencies, 10%.....			98,048	
Foot of Treat's Island to Big Dresden Island, 7.5 miles	Excavation, rock, cubic yards	101,292	3 00	\$303,876	1,279 974
	Excavation, earth, cubic yards.....	616,524	25	154,131	
	Lock No. 5 11-foot lift			482,624	
	Dam No. 3.....			117,790	
	Bridges, 1 highway ..			66,992	
	Land to be overflowed, acres.....	382	100 00	38,200	
	Contingencies 10%.....			116,361	
Big Dresden Island to Marseilles, 24.3 miles.....	Excavation, rock, cubic yards.....	195,971	3 00	\$587,913	1,859,672
	Excavation, earth, cubic yards.....	3,031,413	25	757,853	
	Bridges, 2 highway, 2 railway			268,945	
	Land to be overflowed, acres.....			75,900	
	Contingencies, 10%.....			169,061	

Estimate of Cost, Etc.—Concluded.

Division.	Items.	Quantities.	Price per unit.	Cost.	Total cost.
Marseilles to the middle of Bell's Island, 3.0 miles....	Excavation, rock, cu- bic yards.....	1,176,316	\$ 1 00	\$1,176,316	
	Excavation, earth, cu- bic yards.....	452,837	25	113,209	
	Embankment for canal, cubic yards..	123,910	25	30,978	
	Locks, No. 6, guard, and No. 7, 19ft. lift..			992,131	
	Dam No. 4.....			74,717	
	Bridges, 1 highway..			52,640	
	Right of way, acres...	233	150 00	34,950	
	Contingencies, 10%...			247,494	
					\$2,722,435
Middle of Bell's Island to head of Bull's Island. 3.2 miles.....	Excavation, rock, cu- bic yards.....	117,317	3 00	\$351,951	
	Land to be overflow- ed—acres.....	217	100 00	21,700	
	Contingencies, 10%...			37,365	
Head of Bull's Island to Lover's Leap 10.0 miles....	Excavation, rock, cu- bic yards.....	324,916	3 00	\$974,748	
	Excavation, earth, cu- bic yards.....	331,255	25	82,814	
	Levees, cubic yards..	70,061	25	17,515	
	Locks, No. 8a, 8 foot lift and No. 10a, 13 foot lift.....			925,157	
	Dams, No. 5 and No. 7a			217,758	
	Bridges, 1 railway, 2 highway.....			234,638	
	Land to be overflow- ed—acres.....	1,221	100 00	122,100	
	Contingencies, 10%...			257,473	
					*411,016
Lover's Leap to Peoria, 70.2 miles.....	Excavation, earth, cu- bic yards.....	2,434,206	25	\$608,551	
	Bridges 2 railways....			213,940	
	Removing dam at Henry			14,000	
	Contingencies, 10%...			83,649	
					*2,832,203
Peoria to Beardstown, 71.1 miles.....	Excavation, earth, cu- bic yards.....	9,929,071	25	\$2,482,268	
	Removing dam at Copperas Creek....			16,000	
	Contingencies, 10%...			249,827	
Beardstown to Grafton 89.7 miles.....	Excavation, earth, cu- bic yards.....	15,172,528	25	\$3,793,132	
	Removing dam at La Grange.....			22,000	
	Removing dam at Kampsville			28,000	
	Contingencies, 10%...			384,313	
					\$2,748,095
Grafton to St. Louis, 23.35 miles.....	Excavation, earth, cu- bic yards.....	13,928,000	25	\$3,482,000	
	Paving.....			78,208	
	Dredging, cubic yards	10,000	50	5,000	
	Dam			604,993	
	Bridges, highway and sewer			75,000	
	Right of way—acres..	1,550	300 00	465,000	
	Headgates.....			272,986	
	Lock.....			974,886	
	Contingencies, 10%...			595,807	
					6,553,880
Grand total.....					\$30,097,462

*The Board of Engineers adopts an alternative plan for these two reaches with a total estimate of \$2,951,217, and credits the balance of \$292,002 to the Lower Illinois.

Referring to the dams in the Desplaines and Upper Illinois, the report (p. 12) says: "To keep this (the overflow) at a minimum, it is proposed to make the dams of the movable type which shall have no effect upon the water surface except at low and medium stages."

The board accepts the established pool levels at and above Joliet and avoids water power complications at this locality by a canal 3.1 miles long from dam No. 1 to the head of Lake Joliet, and avoids the Marseilles water power entirely by a canal 3.0 miles long. (p. 12.) "At other places economy in excavation and avoidance of overflow have been the guiding considerations." (p. 10.) "The entire width of the river is closed with a continuous line of chanoine wickets,"

In regard to the development of water power, the report (p. 12) says: "The best development of water power would no doubt in some cases call for a different arrangement. Fewer dams and those of greater height and of the fixed type might, from that point of view, be desirable. The plan submitted is not designed to develop water power, but there will probably be no difficulty in modifying it so as to conform to such development, if those who are to benefit thereby will coöperate with the government. They should pay for the cost of the dams and the damages from flowage, which is no more than they would be compelled to do if the government made no improvement."

A further consideration in determining the project seems to have been the height to which it was considered practicable to adapt the Chanoine wicket system.

The size of locks (600 by 80 feet) was a matter of judgment as to the requirements of the route. As to the depth of the locks, the report (p. 15) says:

"The depth over the miter sills, 14 feet, is adapted to the depth of the waterway prescribed by the law under which the board is acting. It would not be sufficient for the greater depths which would be made practicable in the future by an increased discharge from Lake Michigan. If such future increase is to be permitted, and if full advantage of it is to be taken for navigation purposes, it will be necessary to rebuild the locks, or else to give a greater depth over the miter sills now. The latter may be done if Congress so desires, leaving the general depth of the waterway at 14 feet, as projected. An increase of six feet depth on the miter sills would add about \$1,376,000.00 to the cost of the project."

In regard to the Lower Illinois, the report (p. 18) says:

"The additional flow provided by the Chicago drainage canal is now 4,200 cubic feet per second. It will allow the removal of the present locks and dams, and it makes practicable the maintenance of an open channel considerably deeper than the seven feet now provided by these structures. The increase to 10,500 cubic feet per second makes practicable a still greater open channel."

The report (p. 11) also says:

"In a future not remote, larger volumes of water may be needed for sanitary purposes, and channels deeper than 14 feet will then become practicable in the open alluvial section of the Illinois river."

The report refers to the incidental use for sewage purposes which has always been made of the waterway from Lake Michigan to the Illinois river, recognizes the navigable quality of the sanitary and ship canal from the Chicago river to Lockport, discusses lake level effects of about six inches, due to the abstraction of 10,000 second-feet from Lake Michigan-Huron; cites the conditions under which the United

States may acquire control of the sanitary and ship canal, and calls attention to some 224 claims, amounting to \$4,400,180.00 for damages from overflow on account of the addition of 4,200 second-feet from Lake Michigan.

The Mississippi River Commission says: "The sure way to construct a channel fourteen feet deep from Alton to St. Louis is to construct a canal which shall leave the river near the former place and enter it again near the latter." A movable dam of 2,500 feet long is to raise the low water 14.5 feet at Alton and 6.7 feet at Grafton, making an intermediate pool of 15.5 miles. For sixty-one days of the average year the stage of water is at or above dam level and the open river will be used. The canal is to be eighteen miles long, with a lift lock of thirty feet about three-fourths of a mile above the Merchants' bridge at St. Louis.

No suggestion of doubt as to the practicability of a navigable depth of fourteen feet is conveyed by the report of the Mississippi River Commission nor by that of the Board of Engineers. The latter states, in fact, that the depth obtainable in the open river is a matter of water supply from Lake Michigan.

15. DISCUSSION OF THE FEDERAL PROJECT.

A careful reading of the report of the Board of Engineers, which deals with the problems of most intimate concern to the State of Illinois, indicates that the project is intended to determine feasibility and furnish an estimate of cost, but is not final; indeed, modifications are suggested, as greater depths for locks and a different treatment in the interest of water power. Some matters of State legislation are referred to which invite possible amendments. The State is vitally interested in the development of all its sources of wealth and a careful review of the project is important.

The attention of the board seems not to have been called to the fact that the actual capacity of the Sanitary Canal is some 40 per cent greater than the minimum of 10,000 second-feet called for by the Sanitary District Act, and that the same is completed to the Chicago river, except a strip of clay excavation seventy-three feet wide and 7.8 miles long between Summit and Robey street, Chicago, although these facts were recorded by the Expert Commission of 1901, and published in the proceedings of the Board of Trustees of the Sanitary District of Chicago (June 19, 1901.) Various projects have been made for feeding this volume of water so as to give the canal a navigable depth of twenty-four feet at low water of Lake Michigan (Chicago datum, low water of 1847), but as the 10,000 second-feet was ample to produce the fourteen feet called for by the Act of Congress, the board was not called upon to consider the larger possibilities.

In discussing the effect of the withdrawal of 10,000 second-feet of water from Lake Michigan upon the lake levels, the board has this to say:

"The effect upon the level of Lake Michigan of withdrawing 10,000 cubic feet per second for an indefinite period has been the subject of an elaborate investigation under the office of the Lake Survey in Detroit, and the conclusion reached is that the final effect will be to lower the level about 6

inches. (See Annual Report of Chief of Engineers for 1900, p. 5401, and for 1902, p. 2779, and p. 2825; also for 1904, p. 4120.) Oscillations of more than 6 inches in the level of the lake's surface are very common, often occurring hourly for many hours in succession, while oscillations of 2 or 3 feet within an hour are not uncommon. Still greater oscillations within a year or series of years occur, all from natural causes. Moreover, during a severe winter the discharge of St. Clair river is reduced by ice to less than one-third its normal discharge, the remaining two-thirds being stored up in Lakes Huron-Michigan and raising their levels, and the difference between the total discharge during a severe winter and the discharge during a mild winter will probably equal, or nearly equal, the discharge of the Chicago Draining Canal for a year. A permanent average lowering of six (6) inches in the lake's level, therefore, is not easily observed and will probably not be noticed by navigators. Nevertheless, the effect is real and important. Evidently there is a limit to the amount of water which can be taken from the southern end of Lake Michigan without compensating works at the outlet of Lake Huron."

This statement frankly admits all of the irregularities and uncertainties which baffle any attempt at accurate determination, and makes no valid argument against the ultimate withdrawal of the maximum flow of 14,000 second-feet.

The projected treatment of the Desplaines and Upper Illinois seeks to disturb flood conditions as little as possible. On the contrary, these should be disturbed as much as possible, so as to give more moderate velocities for navigation, with a lower flood line in the interest of land reclamation and with less variation in head at dams, in order to produce more valuable water power. A channel as deep as the Sanitary Canal and ultimately as wide as the normal river bed, especially for the Morris reach, would meet all conditions so far as practicable.

The flow line, as projected for the Lower Illinois, is eleven feet above original low water at Utica and passes over the tops of the dams at Henry and Copperas Creek, being 9.4 feet at Henry, 8.4 feet at Peoria and 7.7 feet at Copperas Creek Lock. The line works out better between Havana and the mouth, being between four and six feet above low water. This flow line, especially for the upper half of the Lower Illinois, may be said to ignore the value of the bottom lands entirely, except as a fish and forest reserve, on the theory that whatever value for cultivation remains since locks and dams were built is to be paid for in damages by the Sanitary District of Chicago. However, the art of hydraulic dredging has so developed as to justify a lower flow line, much lower in the upper half of the river, and a channel not only sufficient to care for the extra water from Lake Michigan, but also to constitute a better drain for the valley. How far this may go is simply a matter of resources to be applied to the work.

16. THE STATE PROJECT.

In 1895 and prior thereto studies were made in the office of the Sanitary District for a provisional project for deep water from Lockport to the Mississippi river. The Sanitary Canal was to be extended two miles, and the same depth carried to Lake Joliet in a pool through the city of Joliet, at forty feet below Chicago datum. Two high lift locks, 750 by 90 feet, were to be provided and the estimated cost was \$8,000-000.00.

A descent of sixty feet between Lake Joliet and Utica was distributed in three dams, and a channel 300 feet wide and fourteen feet deep below crest of dam was to be excavated through the pools at an estimated cost of \$10,000,000.00. To make the depth nineteen feet was estimated at \$17,000,000.00. By raising the levels five feet a depth of twenty-four feet was estimated at \$2,000,000.00 additional.

The flow line for the lower river at Utica was taken at 140 feet below Chicago datum, or four feet lower than that of the recent official project. A channel fourteen feet deep and 300 feet wide was estimated at 66,320,000 yards, and it was assumed that the excavation could be increased to 100,000,000 yards for the estimated cost of \$7,000,000.00. The total estimate was \$25,000,000.00.

A similar treatment is now recommended as follows:

PLAN, LOCKPORT TO UTICA.

Joliet Level, from Lockport to Lake Joliet—Beginning at the dam and power house of the Sanitary District of Chicago, thirty-six miles from Lake Michigan, a lock called lock No. 1, is proposed as shown upon the map, having a normal lift of thirty-nine feet. In the extreme case of very low water in the Desplaines river, very high water in Lake Michigan and the flow through the drainage canal shut off, this lift may be increased to forty-five feet. It is proposed to hold the pool level below the lock at 545 Memphis datum equivalent to minus 41.9 Chicago city datum, and 109.9 Hennepin datum, and to continue this pool level through the city of Joliet to the head of Lake Joliet. The present drainage canal water power channel extension is already complete to a point a mile below the power house and just below the E. J. & E. Ry. bridge, the depth being twenty feet and the width 160 feet all through rock. From this point there is a present depth of ten feet and it is proposed to carry the depth of twenty feet and the width of 160 feet through the rock to the point where the channel empties into the upper basin formed by the present dam No. 1, in Joliet. From here it is proposed to carry a depth of twenty feet and a width of 300 feet through the city of Joliet to a point near McDonough street, removing the present dam at Jackson street, and embracing within the new channel the I and M canal prism on the right bank, and property belonging to the Sanitary District of Chicago on the left bank. A levee will be constructed on the left bank and nine bridges must be raised or rebuilt. Below McDonough street, the pool above the dam will widen out as shown on the map, being contained on the left by an earth levee and on the right by the I and M. canal bank. The power house, dam and lock will be located, as shown on the map, below Brandon's road, and the location of the road will be changed so as to cross at the lock by a bascule bridge, and to run over the top of the turbine chambers at the power house. Hickory creek will be diverted into a channel parallel and adjacent to the entraining levee and will empty into the river below the power house. An intercepting sewer paralleling the left bank and emptying into Hickory creek is proposed. About 698,750 cubic yards of rock will be excavated, two railroad bridges and seven highway

bridges will be reconstructed, and dam No. 1 and the old canal lock will be removed. The equity in the plant at dam No. 1 will be transferred to the new development at Brandon's road. The cost of this section is estimated at \$7,775,164.00.

Dresden Heights Level, Lake Joliet to Big Dresden Island—Below the Brandon's road development, a pool fourteen miles long is created by a dam (No. 2) at the mouth of the Desplaines river, just above the confluence with the Kankakee. This is a spillway dam and the channel is carried about a mile farther down between a concrete entraining wall on the left and the right bank of the I. and M. canal on the right, embracing the I. and M. canal prism. The crest of the spillway dam is 518 Memphis datum, equivalent to minus 68.9 Chicago city datum, and 82.9 Hennepin datum. Some land is flowed in this plan and some channel excavation is necessary at Treat's Island, and the upper end of the pool. The channel excavation will have a bottom width of 300 feet and a depth of fourteen feet. It is proposed to construct an earth levee on the left of the channel from a point above Riley's creek, and to divert Riley's creek into a ditch parallel and adjacent to this levee emptying into the Kankakee river at its mouth. The lock and power house will be located at Big Dresden Island as shown on the map, the island chute being utilized for a tail race. This plan relieves the power plant of back water difficulties from the Kankakee and gives a good alignment for the waterway. Two highway bridges must be rebuilt. The amount of channel excavation is about 97,777 cubic yards, about 351,155 cubic yards of earth levees, and 135,000 cubic yards of concrete entraining walls. The estimated cost of this section is \$3,354,030.00.

Marseilles Level—Big Dresden Island to Bell's Island—Below Big Dresden Island a single pool extends to the head of Ballard's Island, a distance of about 24 miles. The dam (No. 3) creating this pool is an overfall or spillway dam from the head of Ballard's Island to the right bank. The level of this pool at the downstream end is 495 Memphis datum, equivalent to minus 91.9 Chicago city datum and 59.9 Hennepin datum. The crest of the dam is placed at an elevation that will allow all of the discharge over 14,000 cubic feet per second to flow to the Marseilles dam and power development. This 14,000 cubic feet per second is the volume of the artificial flow from Lake Michigan, and all of the discharge in excess of this amount is the natural flow of the stream, the same volume that was utilized at Marseilles before this increment was added. The diversion of the artificial flow leaves the Marseilles power development only the natural flow of the stream. This construction is a diversion which removes from Marseilles all danger of overflow during flood periods. There is approximately 285,259 cubic yards of channel dredging necessary in this pool and the cuts, where necessary, will have a bottom width of 300 feet, and a depth of 14 feet. From the head of Ballard's Island the waterway will follow the Island Chute and a channel on the left bank of the stream as shown on the map. From the Ballard's Island dam this channel will be contained on the river side by an earth levee running nearly to the head of Bell Island, about three miles below. This levee will be rip-rapped on its inner slope. No levee will be built on the left of the channel as the overflow

is inconsiderable, as will be shown by an inspection of the 495 contour. At the end of this artificial channel and opposite the head of Bell's Island will be located Lock No. 4 and the power house. There will be approximately 2,862,865 cubic yards of excavation in this artificial channel. Two railroad bridges and three highway bridges must be reconstructed. The estimated cost of this entire section is \$3,643,847.00.

Utica—Level. Bell's Island to Utica—From the foot of the Marseilles Canal a pool extends to the head of Delbridge Island a distance of about ten miles, where dam No. 4 is located. The level of this pool at the lower end is 466 Memphis datum, equivalent to minus 120.9 Chicago city datum and 30.9 Hennepin datum. The channel follows the river as shown on the map except at the cut-off through the Sheehan Island Chute, and the dredging necessary amounts to about 684,165 cubic yards. The dam at the head of Delbridge Island is an overfall or spillway dam, permitting the flood discharge to flow down both branches of the river on either side of the chain of islands. The channel has exit from the pool through the centre of the dam and extends in an artificial cut, 300 feet wide on the bottom and 14 feet deep, between containing levees through the chain of islands; Delbridge Island, Island No. 4, Leopold Island, Island No. 1, and Plum Island, to the lower end of Plum Island where the power house and Lock No. 5 are located. This development is accomplished with the least excavation and the least overflow, the flats above Utica and on the right bank being in this manner absolutely protected from overflow. The amount of excavation in this channel is approximately 1,744,052 cubic yards. One highway and one railroad bridge must be reconstructed and the cost of the entire level is estimated at \$3,030,157.00.

From Lockport to Utica five lift docks, four pools and two canals, replace the eight lift locks, one guard lock, seven levels and two canals of the Federal project. No rock will be excavated below Lake Joliet that cannot be removed by suitable dredges.

Utica to Grafton—The low water elevation below the Utica bridge is 446.6 Memphis datum, equivalent to minus 140.3 Chicago city datum and 11.5 Hennepin datum. Dredging this channel, as will be necessary in any theory of development, will lower this low water surface elevation materially and increase the available head at the power plant.

The ultimate flow line for the Lower Illinois river is assumed at 146 feet below Chicago datum at Utica, or six feet lower than the low water surface, and at 170 feet below Chicago datum at Grafton, or 1.7 feet below that of the Federal report, and five feet above the low water taken by the Mississippi River Commission. The fall of the river for this flow line will be twenty feet, or ten feet less than the natural declivity. Sufficient study has been given the matter to show that with the increased volume of 40 per cent to 50 per cent (14,000 to 15,000 second-feet) above that considered by the Board of Engineers, a depth of at least eighteen feet can be produced in a commodious channel, and that twenty-four feet can be carried as far as Peoria over the easy grades above that

point. This depth (eighteen feet) is as great as can now be carried through the intermediate channels of the great lakes at standard low water, and the lakes were lower by one foot in 1895.

On any theory of improvement a dam is required in the vicinity of Alton, but the change in flow line by 1.7 feet at Grafton will require a lower elevation by about two feet, or at 171 feet below Chicago datum. The canal from Alton to St. Louis would also require to be lowered by two feet. The question is raised as to whether the dam could not be placed two or three miles farther down stream and perhaps enter the river again at a higher point, or be made shorter. It is sufficient now, however, to know that the problem can be solved in the way proposed. The first purpose is obviously to open up waterway communication which already exists over this division, and there will be ample time to ascertain any modification or alternative for this part of the project, particularly from the dam to the harbor of St. Louis.

17. THE LOCKS.

The nine locks between Lockport and Utica are estimated in the Federal plan at \$5,128,077.00. The five locks of the State plan with 24 feet of water on the miter sills are estimated at \$5,929,690.00 or \$801,613.00 more than the Federal estimate. The dimensions of locks recommended by your commission are,—length 900 feet between hollow quoins, width 80 feet, depth over miter sills 24 feet.

The width of these structures is limited by the permanent works in the Chicago Sanitary and Ship Canal, the channel clearance at the Butterfly Valve in Lockport being eighty feet. If this condition did not preclude discussion, it might be pointed out that the Federal Government is constructing a lock at Sault Ste. Marie with a width of 80 feet and length of 1350 feet, after having used for many years a lock 100 feet wide. The Poe lock is 100 by 800.

A greater length than 600 feet is, however, justified for this route. One of the considerations which led the board to adopt a lock as long as 600 feet was to enable lake ship builders to deliver the output of their yards to customers at the seaboard, but since the report was written a ship 600 feet long has been launched for the lake trade, and another over 600 feet long is on the ways. Longer ships are in use on the high seas, and no reason exists why crafts of all kinds, both long and wide, should not be built in lake yards and delivered by this route, except the limitations of lock dimensions.

The Board of Engineers on Deep Waterways, in their report (1900) on deep waterway between Lake Erie and the Hudson river, adopted a lock dimension of 740 by 80 feet, or 140 feet longer than in the Federal project of the southern route. There are special reasons, owing to their relations to river navigation and fleet towing and to ship building, why these locks should be made longer and of the dimensions proposed, 900 by 80 feet.

The extra money for the larger locks should not be considered as against the construction of possible barriers to future development. It is part of the irony of fate that the conditions have outgrown, on admitted

points, the provision of the board, even before its recommendations could be considered. The history of public works is largely a history of utilities that were obsolete or outgrown before they could be completed. Project your works on such a scale of magnitude that no one for a century could wish them larger, was the spirit of the advice of Senator Edmunds to the first International Deep Waterways Commission.

18. THE WATER POWER.

Fixed dams, good heads of twenty feet or more and as little variation from flood conditions as possible, are prime elements in a good water power. Heads of twenty to forty feet where practicable reduce the number of locks and give more ample pools for navigation, and capacious channels give less back water, thus reducing slopes and overflow of marginal lands and moderating the velocities. The best treatment for water power may also be the best treatment for navigation. Flowage may be increased in the vicinity of dams and in the lower reaches of pools, but this is more than offset by the betterments below. Happily, between Joliet and Utica the treatment does not involve serious flowage questions, and the constructive advantages far outweigh the value of lands that may be taken. Modern practice locates water power dams at the foot of rapids rather than at the head, and generally down stream as far as possible, in order to mask the effect of floods.

When the channel has been fully developed so as to give moderate velocities and low slopes in floods, the effective horsepower on the turbine shaft, with 14,000 second-feet from Lake Michigan will be as follows:

	Head.	H. P.
Brandon's Road, Plant No. 1	24	38,182
Big Dresden Island, Plant No. 2	18	28,636
Bell's Island, Plant No. 3	26	41,364
Utica, Plant No. 4	20	31,818
Total		140,000

The above estimate assumes that 10.3 feet out of the total fall of 98.4 feet, will be consumed in slope, back water and other impediments to flow, and that the effective head will be 88.0 at low water.

All of these powers, with the exception of the one at Utica, have practically full value under flood conditions. The power at Dresden Island is so located as to escape flood water obstruction from the Kankakee, and will not be seriously affected even by a simultaneous flood in both the Desplaines and the Kankakee. The Bell's Island power takes only the artificial increment of flow from the Marseilles development, and removes from Marseilles all danger of overflow during flood periods. The Utica power will always be affected by flood conditions in the river below, but extreme floods are exceptional and a radical improvement of the Lower Illinois should better these conditions. At low water the head will be twenty feet, but this should be increased by river improvement to twenty-six feet. In an ultimate development an installation adapted to large variations in head will make this power available.

Power rentals on a basis of \$25.00 per horse power per year should show a minimum net earning of \$2,500,000.00 or a return of 12½ per

cent on construction cost, though the true result would probably be far in excess of this. As the market developes, this power may reach an investment value of \$1,000.00 per horse power as in older countries, and it may produce taxable wealth to three or four times this amount. Such a resource the State cannot afford to ignore.

The water power is, however, strictly a by-product of the waterway, which is of national and even international concern. No existing power, now or in the future, should be permitted to condition in any way or interfere with the best possible waterway development, and the Legislature may wisely safeguard the appropriation of waters for waterway and sanitary purposes.

In a public utility so fundamental as water power, it is a question as to how far it should vest in private control. The Sanitary District has developed a power at Lockport, and the power at dam No. 1 in Joliet is operated under a lease from the State, the equity in which may be transferred to the Brandon's road development. Ultimately the control of all may be wisely vested in some public agency, Municipal or otherwise, under proper restrictions, but the immediate development and sale of power from the four plants considered in this report should be entrusted to the construction commission, in order that the power revenue may contribute as soon as possible to the fixed charges, operating expenses and refunding of construction cost.

The following table gives a synopsis of the estimate of construction cost:

STATE PLAN.

Estimate of Cost—Lockport to Utica.

Division.	Item.	Quantity.	Unit price.	Cost.	Total cost.
Lockport to Brandon's Road.....	Lock No. 1.....			\$1,185,938	
	<i>Excavation:</i>				
	Rock, cubic yards.....	698,750	\$2 50	1,746,875	
	Concrete, cubic yards.....	8,277	2 00	16,554	
	Retaining walls.....	104,777	1 00	104,777	
	Concrete retaining walls.....	248,560	6 00	1,543,360	
	Earth and rock, back fill.....	456,518	50	229,259	
	Removal dam No. 1.....		Lp. sum	10,000	
	Removal canal lock ..		do.....	5,000	
	Rebuilding bridges, 2 railway, 7 highway..			797,463	
	Power house.....			900,000	
	Lock			1,185,938	
	Sewer diversion			50,000	
					\$7,775,164
Brandon's Road to Dresden Island.....	Excavation, channel, cubic yards.....	97,777	25 \$	24,444	
	Levees, cubic yards..	351,155	30	105,346	
	Concrete, dam, cubic yards	7,750	15 00	116,250	
	Retaining walls.....	135,000	6 00	810,000	
	Crib, linear feet.....	7,500	10 00	75,000	
	Lock.....			1,185,938	
	Power house.....			900,000	
	Bridges, 2 highway..			137,052	
					3,354,030
Dresden Island to Bell's Island.....	Excavation, channel, cubic yards.....	285,259	25 \$	71,315	
	Marseilles Canal.....	2,862,865	30	858,859	
	Rip rap.....			189,150	
	Lock.....			1,185,938	
	Dam			117,000	
	Power house.....			900,000	
	Bridges, 3 highway, 2 railway			321,585	
					3,643,847
Bell's Island to Utica	Dredging, cubic yards,	684,165	25 \$	171,041	
	Excavation and levees	1,744,052	30	523,215	
	Dams	5,000	15 00	75,000	
	Lock.....			1,185,938	
	Power house.....			900,000	
	Bridges, 1 highway, 1 railroad			174,963	
					3,030,157
					\$17,803,198
					340,000
					1,814,319
Grand total.....					\$19,957,517

19. LAND RECLAMATION.

The lands in the Morris reach of the Upper Illinois subject to overflow, aggregate 7,780 acres. When the channel opposite is fully developed, not over ten to twenty per cent of these lands should be within flood limits, and these should be materially bettered. Other lands along the Upper Illinois and Desplaines rivers do not aggregate 25 per cent of the total value, and some of these will be benefited and others damaged.

The lower Illinois valley under the high water of 1904, aggregates 363,869 acres. Above the high water of 1904, there are probably 65,000 acres reached by such floods as those of 1844 and 1858, which occur two or three times in a century. Of the area under the flood of 1904, the present water area, with the existing locks and dams, is 78,216 acres, of which 28,811 acres lie within the river bed and the remainder in the outlying lagoons, bayous, etc. The land area proper is 258,653 acres. A further deduction for marginal lands and other low areas, will probably reduce the land area to about 250,000 acres subject to reclamation. No estimate has been made of the relative elevation of these lands.

The entire area under the greatest known flood may be taken in round numbers at 430,000 acres. Of this, 65,000 may be flooded two or three times in a century, and another 65,000 acres, once or twice in a decade. Some 185,000 acres are subject to ordinary floods, 35,000 acres of marginal and low areas are generally under water, and 80,000 acres are permanently covered by water under existing conditions.

The 130,000 acres subject to rare and occasional floods are valuable for agriculture, but any scheme of reclamation will benefit these lands. The 185,000 acres cannot develop a large value without protection from overflow.

The 80,000 acres of submerged lands have a high value for fish culture, the present yield bringing \$10.00 per acre to the fisherman, while the consumer pays double. It is not too much to expect that this crop will increase to a value of \$15.00 to \$20.00 per acre in the future, or amount to \$1,200,000.00 to \$1,600,000.00 annually. Any policy of reclamation should jealously guard this source of wealth.

The 220,000 acres in marginal low lands and under ordinary floods, ought to be worth \$5.00 per acre per year under systematic forestry. Low land timber reproduces rapidly and is now valuable, and will become more valuable in the future. An annual crop of \$1,100,000.00 from such a source is not to be deprecated.

So the 300,000 acres of water and now inferior lands may easily yield a revenue of perhaps \$2,500,000.00 per year in the future, which is not a bad showing for property presumed to have little or no value. From the merely waterway and sanitary standpoint, it would have been wise to have purchased these lands outright (at a cost less than the claims for flowage against the Sanitary District now amount to) and to have taken up the radical improvement of the river at leisure. A generous depth for navigation could have been produced as proposed by the Board of Engineers, and this channel could have been bettered at convenience, and eventually the lands valuable for agriculture could have been reclaimed and sold.

Considerable progress has already been made in reclaiming lands. An area is enclosed by levees along the river front and up tributaries to the bluffs, and a pumping station installed to keep down the inside waters in times of flood. This treatment is extending to the favored tracts, but there are large areas beyond the scope of ordinary enterprise.

The physical problem of reclamation is no easy one. The river bed within the banks is of limited capacity, not more than 20 per cent to 30 per cent of the probable flood volume when restricted to the course

of the stream. The bottoms are great reservoirs which prolong the duration of floods and lessen the maximum. At Beardstown the flood levels of different years show divergence increasing toward the mouth under the diverse influence of the back water from the Mississippi, and this again in some notable instances is affected by the Missouri. Under ordinary conditions, the flood volume near the mouth is not over half what it would be if restrained to the river course through the valley, but in some years, like that of 1904, when the Mississippi was relatively lower, the volume reached two-thirds of the extreme flood expectation. Such influences show up in an enlarged capacity of the river bed as the mouth is approached.

If the general horizon of the river bed could be lowered ten to twelve feet and the excavated material used to fill in the foreshores and raise the banks, thus forming a regular channel, a moderate additional bank height would be sufficient. If such plan was extended up the tributaries to the bluffs, complete protection would be afforded, but the enclosed areas would probably require pumping in wet years. Such a plan would involve the removal of 300,000,000 to 400,000,000 cubic yards of material, and require a long time in execution. Below Beardstown, and increasing in degree toward the mouth, the problem is complicated by back water effects from the Mississippi.

Any radical change in flood conditions at the mouth involves a heroic undertaking, nothing less than a change in the course of the Mississippi and possibly of the Missouri. No justification has yet appeared of sufficient weight to lead to official consideration, and such project would probably be regarded as in advance of the art and without sufficient reason. The matter has not been sufficiently studied to warrant suggestions at this time.

In the report of 1868, Colonel Ulffers suggested that tributaries should be diverted and reach the river through the ponds and lagoons in order to arrest the supply of detritus from the uplands. Such a policy, if practicable, would be conservative, but no fear is entertained in regard to the deterioration of the river when it has been reformed and supplied with a generous volume of water in the dry season. These back waters are valuable fish preserves which must not be lost sight of in any plan for land reclamation and river improvement. The whole subject matter is one that requires further study.

Meantime the matter reverts to what may be justified in the interests of navigation, and without prejudice to existing interests, and to the incidental benefits which may accrue from the manner in which the work is prosecuted. A channel eighteen feet deep below the flow line already suggested is justified for purposes of navigation and is within the resources that should be applied to the work. Such a channel will care for the increment of water from Lake Michigan and be a betterment to flood conditions. The material dredged from the river can and should be so wasted as to fill in the foreshore and build up the banks, thus forming a more regular river prism. Such a project carried out with due regard to all the benefits that may be conferred, will reduce materially the problem of land reclamation.

If the valley belonged to one party, there could be no question about the carrying out of some such program. But there are many ownerships, varying interests and diverse mentalities, and it may be necessary to invoke the strong arm of the State to insure coöperation.

20. GENERAL REMARKS.

In May, 1889, the General Assembly declared, among other things, that the policy of the State of Illinois is to procure the construction of a waterway not less than fourteen feet in depth throughout the river from Lake Joliet to the mouth of the Illinois, designed in such manner as to permit progressive development to a greater capacity. At that time the data available in regard to the removal of such great volumes of material in similar work were very meagre, the most pertinent being the experience of the Canadian engineers in dredging alluvial clays in the ship channel through Lake St. Peters in the Lower St. Lawrence.

Eighteen years have passed and projects then regarded as visionary by many have come to be accepted by all. The resources of engineering have multiplied. The work on the Chicago Drainage Canal halved the cost of rock excavation and cheapened earth excavation. Steam shovels increased from twenty-five ton shovels to seventy-five ton shovels, and hydraulic dredging was greatly developed, an art little known and experimental when the Sanitary District Act was passed. Today hydraulic dredges are built that will handle regularly 200,000 to 300,000 yards per month and deliver the excavated material a mile away through pipes if required, and at a fraction of former cost when the material is suitable.

Wonderful results are being obtained by hydraulic dredging in the St. Lawrence and elsewhere, and it is believed that no better material for such machines was ever laid down than that in the bed of the Illinois river from Utica to the mouth. It is not too much to presume, therefore, that the eighteen foot channel, with the lower flow line suggested, can be carried through the Lower Illinois for the sum estimated for this division of the route. It is a matter of the proper fleet and an annual allowance to keep it busy.

The art of engineering is advancing so rapidly that the dreams of yesterday are sober projects tomorrow. The resources and wealth of this land are developing with like speed. Difficulties that seem insurmountable at a distance disappear as we approach them closely. A solution that is desired and sought is usually found, and the spirit of negation generally stands for mere mental limitation. That a proposition should be practicable has come to be a question of the number of people who think it worth while.

The waterway between Lake Michigan and the Mississippi river becomes the most important work in the nation whenever the Congress rises to the policy of a related waterway system, as distinguished from an amicable distribution of public funds to local and detached works.

Part IV. Resume and Conclusions.

21. LAKE ILLINOIS.

The depths available at standard low water of the great lakes (Report International Deep Waterways Commission, 1897) are: Saulte Ste. Marie, 17.9 feet; St. Clair flats, 18.8 feet; Limekiln crossing, Detroit river, 19.3 feet. The mean stage of Lake Michigan-Huron adds 1.6 feet. Lake carriers are moulded for a loaded draft of eighteen feet.

The increment of water than can be made available through existing works at Chicago makes practicable throughout the Lower Illinois a minimum depth of eighteen feet or more. The normal low water volume of the Illinois will increase this depth and it will also increase with the increase of water supply due to higher lake stages, so that the entire route of 367 miles between Lake Michigan at Chicago and the city of St. Louis will have at all times a depth equivalent to that available for lake navigation.

It is also practicable to extend the depth of the Chicago Sanitary and Ship Canal, or twenty-four feet, throughout the Desplaines and Upper Illinois and down to the city of Peoria, 170 miles from Lake Michigan, and its extension to St. Louis is a matter of water supply. By utilizing the stages of water in the eighteen foot channel below Peoria this depth may be carried through for four to six months of the average year. Such a depth (twenty-four feet below standard low water) is a proper depth for lake navigation in the future, to be reached by lake regulation and by deeper intermediate channels.

The average duration of ice for five points—Chicago, Morris, Seneca, Peoria and Pearl—is fifty days (Jan. 3-Feb. 22) and ranges throughout January and February for the several localities. Such ice as would interfere with navigation does not occur in some years and in others the route could be kept open by means of ice breaking boats. The Chicago Drainage Canal has not been frozen over in eight winter seasons since January, 1900. The fire tugs have patrolled Chicago river for many seasons and Lake Michigan is navigated throughout the winter. Lake Superior is closed at the Soo for an average of 142 days, or the season of navigation scarcely exceeds seven months, as against ten to twelve for the southern route. Lake Michigan is shut off from Lake Erie for 120 days, and this is the best that can be had in a waterway to the Hudson river, while by the St. Lawrence and Montreal the period is 130 days. In other words, ice will close an eastern route for four months or more, as against two months or less for the southern route.

The Illinois waterway between Chicago and St. Louis developed as proposed, adds the equivalent of another lake, more resourceful than any of the great lakes system. Its utility is enhanced rather than impaired by the fact that its banks are within bridging distance and the people of opposite shores may have a community of interest rather than alien diversity. If this waterway was isolated and had only the minor tributaries of its local basin, it would be on a par with the other great lakes, and certainly the fact that it connects on the south with over 15,000 miles of navigable waters cannot be urged in disparagement. The great lakes have no adequate connection with the eastern seaboard, either by way of the St. Lawrence or the Hudson, the one now under way is not commensurate, and an adequate outlet is not even promoted, and yet this does not distract attention from the importance of the lakes themselves, and no such argument can be seriously advanced against the utility of this new lake, with its far more adequate seaboard outlet. That there is now no great commerce along the route and between the two great cities at its termini is a chief reason for and not against this waterway. The wise promoter projects his transportation lines into resourceful lands for the purpose of developing commerce. If they are already fully developed there is no justification.

The Illinois waterway joins the two metropolitan cities of the continental interior, and in the 367 miles of its length passes through the most resourceful section of the Mississippi valley. It crosses the middle of the great American corn belt. It passes through manufacturing towns—Joliet, with its steel and wire mills; Morris; Ottawa, with its glass sands; LaSalle and Peru, with their zinc smelters; Peoria and Pekin, with distilleries that pay one-third the internal revenue tax of the United States; Havana; Beardstown; Grafton, with its quarries; and Alton. The Illinois valley counties contain some of the best coals in the State, which can be connected with the river by short sections of railway and loaded directly into coal barges.

All these capabilities will be greatly stimulated and multiplied by the development of 140,000 horse power in the Desplaines and Upper Illinois valley, the creation of an industrial situation which of itself justifies both lake and river transportation. The 350,000 acres of alluvial lands to be bettered and reclaimed and available for high class truck farming, and the 80,000 acres of water with a fish crop only second to that of the Columbia, are resources not to be overlooked. There are several tributaries that can be developed as feeders, and there is also the Hennepin canal from the Upper Mississippi.

The Illinois waterway is along the line of primary markets—Duluth, Milwaukee, Chicago, Peoria, Quincy and St. Louis—the places where commodities are actually bought, warehoused and held for future sale and delivery, and where the holder may choose in forwarding by water or rail. This is the line of pooling points for the eastern trunk lines and the division in freight classification between the eastern and western roads. All the east and west traffic of the United States sweeps through the neck of land between Chicago and St. Louis. From every stand-

point of traffic movement, the Illinois waterway is on the one location of advantage in the long distance hauls, to gather traffic and profoundly affect commercial movement.

22. THE MISSISSIPPI OUTLET.

From St. Louis to Cairo is the link of 186 miles which joins the northern river system to the southern system, and from Cairo is 1,072 miles to the Gulf of Mexico, from Lake Michigan, 1,625 miles. The criterion for the route is what may be had through the Middle Mississippi from St. Louis to Cairo. The natural depth available is about twelve feet for five months of the average year. Assuming the river to be so regularized as to give a minimum of eight feet with the natural low water volume, and restrain the bar horizon below a fixed plane, the Chicago increment should add about two feet. Fourteen feet would then obtain for about nine months and eighteen feet for over six months. A like increment from reservoirs at headwater of the Upper Mississippi would prolong these periods by more than a month. Such periods can be compared favorably with the open season of the northern lakes. During the low water season hydraulic dredges can keep open a fourteen foot channel. During the high water depths greater than eighteen feet will be available. All these estimates are tentative, but there is no reason to doubt the possibility of obtaining available depths in the Mississippi if the problem is entered upon with serious determination.

It may be well to point out in this connection that a commensurate waterway will have a greater low water depth at the northern end, where the fluctuations are within narrow limits. A waterway with a uniform depth under the average stage is a more rational proposition than one carrying only such depth throughout as obtains at low water under moderate improvement in the Middle and Lower Mississippi.

With such improvement of the Mississippi as has been indicated, the lake marine can be employed on the high seas and in the coasting trade for four to five winter months. If they have to pass down partly loaded in the early winter, they can usually return with a full cargo on the spring rises. The lake shipbuilders can also deliver their output in competition with coast yards and even undersell the foreign builders.

No one deprecates the utility of an available outlet to the sea for the great lakes region. North and south commerce is an incident of climatic difference in product, when population has ceased to be migratory along parallels of latitude. This will grow in importance as the country ages, and the lakes and gulf waterway will be the artery of such a movement.

South from St. Louis and east and west of the Mississippi river is the great undeveloped region of the United States, with more resources unexploited than in any other part of the domain. The timber of this region is needed in the north. The alluvial lands below Cairo embrace 20,000,000 acres, an area four times as great as the arable land of Egypt and under a climate as favorable. It must be protected and the river fixed in its course, which also means its improvement. These are the cotton fields of the future, and naturally it goes to the northern water

power at the homes of the mill population of a more temperate climate.

All the possibilities do not have to be developed in a day. We need to know what they now are and what they may become with the growing art of engineering and the growth in resources, in order to properly project the permanent works, so a progressive development may follow.

23. CO-OPERATION.

In early days the Federal Government made grants of land from the public domain to assist states in constructing canals, and under such grants, canals were built in the states of Ohio, Indiana, Illinois and Wisconsin, and the original canal at Saulte Ste. Marie by the state of Michigan. The Illinois waterway was authorized by Congress in 1822 and 1827, and the present enterprise is simply the outgrowth of modern conditions and an adaptation to the needs in sight—in fact, a fuller expression of the purposes of the original promotion and the intent of Congress. From the beginning, this waterway has been recognized as of national importance, and even of international concern.

The State of Illinois, in response to the treaty of Washington, (May 8, 1871) by Act of the General Assembly, approved April 4, 1872, granted "the use of the Illinois and Michigan Canal, and all other canals that may be constructed by this State" to the citizens of the Dominion of Canada, on equal terms with citizens of the United States.

It is not proposed here to discuss recent international phases of this enterprise further than to say: The State of Illinois has acted under proper federal authority and within her sovereign sphere; she has the right to invoke the spirit of comity between public utilities; aside from its incidental use, the investments for all the people and under federal control; and the damages are nominal in comparison to the benefits, and can be readily compensated by such works as should be a part of any scheme for deeper navigation in the Great Lakes. It is presumed that the international consideration proceeds under a spirit of comity and not on any basis of international law, and that no sovereign rights are to be surrendered, certainly none in derogation of the rights of states, that the issues reduce to a matter of remedies, and that there is no disposition to indict the enterprise because it was not queered by consulting everybody in advance. As long as the enterprise continues along lines of sound public policy, there is no reason for apprehension.

After the civil war, 1866-9. The United States made surveys of the route, and later of the northern section as part of the northern transportation route to the seaboard, all for the extension of steamboat navigation of six to seven feet to Lake Michigan at Chicago. The State constructed the locks and dams at Henry and Copperas Creek out of surplus canal revenues. Later the United States undertook the works at LaGrange and Kampsville (opened in 1889 and 1893) and completed the same, notwithstanding the protest of 1889, the State having changed its policy to a deep waterway, not less than fourteen feet deep, in conjunction with a water supply from Lake Michigan. This change in policy and the work that followed on the Chicago Divide occasioned

a hostile attitude, expressed through the local army engineer at Chicago, and in recent years only (since 1898-9) has consideration for the policy of the State of Illinois been shown by the federal authorities. Friction and strife have also existed between the trustees of the Sanitary District of Chicago and the State Canal Commissioners.

All these matters have embarrassed the waterway project. It may be that the local outlook has at times been too narrow and has resulted in delays and wastefulness. It may be also that all the friction, strife and controversy has been necessary and only exhibits the American fashion of debating grave issues, and that, after all, we are only now prepared to clearly present the right thing and have it generally accepted. Be that as it may, the question of divided jurisdiction with diverse purposes, is one for consideration. At present the United States has charge of the Illinois river below Copperas Creek, and approves the plans for the Chicago river improvement. The State looks after the locks and dams at Henry and Copperas Creek and the Illinois and Michigan Canal. An agency of the State, the Sanitary District of Chicago, controls the ship canal between Chicago and Joliet, and may enter upon the river below to remove obstructions, or do such work as will avoid overflow consequent upon introducing water into the Desplaines and Illinois rivers.

That this divided jurisdiction and diversity of purpose can be coöperated with proper regard for the vested rights of the State and the federal control of navigation is not unreasonable. As an instance of such coöperation, the lowering of the Kampsville dam is notable. The crest of this structure was lowered two feet by the Sanitary District of Chicago, under Act of Congress, to reduce the overflow of marginal lands and to relieve the district from claims for overflow damages.

The coöperation most effective and most to be desired is federal acquiescence.

24. ILLINOIS.

The creative forces of the continent made the region of the Great Lakes a part of the Mississippi valley, and Professor G. K. Gilbert, U. S. Geologist, fixes the time when it will return to its ancient outlet. It lies within the art and the resources of the present day to divide the outflow of the Great Lakes, so as to give deep water to the Gulf of Mexico without impairing any of the possibilities for deep water to the Gulf of St. Lawrence.

What is feasible from the Great Lakes to the eastern seaboard has been the subject of elaborate technical investigation, and is well understood. This report indicates what may be practicable for the southern half of the continental route. From the standpoint of the engineer and from that of the financier, a deep waterway from the Gulf of St. Lawrence to the Gulf of Mexico is practicable, and the statesmanship of two nations should be broad enough to bring it to pass.

The Illinois waterway between Chicago and St. Louis is the middle division between the two seaports, Montreal and New Orleans. The outlet which has been opened across the Chicago Divide from the basin

of the St. Lawrence to the basin of the Mississippi, makes it now practicable to develop the Illinois waterway on the scale of lake navigation. Illinois is perhaps more interested than any other State in the extension of her waterway to both the eastern and the southern seas.

Illinois is not only in the most favored position on the great trunk waterway, but her position in relation to the primary laterals is equally significant. All the waters that drain the western slopes of the Allegheny Mountains from Northern Alabama and Georgia to Western New York, come to her shores through the Tennessee, the Cumberland and the Ohio, with their many navigable tributaries. The Missouri brings the eastern slopes of the Rocky Mountains and the great plains from Kansas to the Canadian northwest. From the Winnipeg basin in the far north the water route comes southward by the Minnesota and the Upper Mississippi. All possible water routes between the basin of the St. Lawrence and the basin of the Mississippi trail her borders, whether from Lake Superior or Green Bay to the Upper Mississippi, or from Lake Erie by the Ohio or Wabash. At Cairo, Illinois stands at the head of rich low lands, and another river system reaching to the Gulf of Mexico. Half the waters of the United States gravitate to the shores of Illinois, and she is the natural focus of a waterway system continental in scope. No other State is to be more benefited by a broad waterway policy, national and international.

Illinois within her borders has many streams as available as some that find their way into the river and harbor bills, and she has favorable topography for uniting the same into a domestic waterway system whenever economic conditions justify. She is therefore in position to extend the benefits of a national waterway system to all sections of her domain.

There is every reason for the State of Illinois to earnestly lead in the promotion of a national waterway policy, and there is also every reason for her to set an example to sister states in a domestic waterway development. When the United States has developed a comprehensive plan and adopted a systematic policy, we must expect the national function to be restricted to the broad outlines and arteries of a system, and that local waterways and ports will be relegated to the states. When some such program shall come to pass Illinois will receive the recognition to which she is entitled by reason of her potential position.

Meantime it may be worth while to consider whether the State of Illinois should not, through some appropriate agency, undertake the development of the route through the State, receiving from the United States such subsidy as it may choose to give. There may be hidden wisdom in such self-reliance as has marked the policy of the state of New York, and it may be that the example and influence of two such states will be sufficient to lead the Federal Government into a national waterway policy.

APPENDIX

CHICAGO, ILL., Sept. 2, 1908.

Honorable Commissioners, Internal Improvement Commission of Illinois:

GENTLEMEN—I submit herewith statement of work done and moneys expended on the Shawneetown levee improvement.

Bids were opened for this work on Aug. 22, 1907, and were as follows:

McCann Bros.49½ cents per cu. yd.
Costello Bros.51½ cents per cu. yd.
Cash & Moulton53½ cents per cu. yd.

These bids were all rejected as too high, and after further advertising bids were again opened on September 3, 1907, as follows:

McCann Bros.44½ cents per cu. yd.
Fisher (McCann Bros.)45½ cents per cu. yd.

These bids were rejected as too high on October 7, 1907, and on Oct. 1, 1907, by direction of your honorable body, Mr. T. W. Clayton was instructed to proceed with the work by force account. Active construction was started on October 9th, and the work carried on continuously to December 31st, when it was closed down for the winter.

Work was resumed on June 4, 1908, and carried on continuously to completion on August 21, 1908.

The following table shows the location of fills, yardage and haul:

Location of Fill.		Yardage.	Haul.
Sta.			
78—88.....		10,050	1,700
101—108+50.....		1,955	3,300
111—Old Cellar.....		140	3,800
115—Cellar.....		55	4,200
134—Cellar.....		45	1,900
144—151.....		5,810	1,400
153—158.....		3,130	1,250
30—38.....		16,200	1,150
54—56.....		950	2,100
Average haul.....		38,955	1,466

The location of fills may be found on the accompanying map by reference to stations described in the above tabulation.

Construction Cost Exclusive of Administration.

Pa rolls \$14,731 07
To s 293 84
Total \$14,924 91

Fair auction value of tools turned over to city of Shawneetown and inventory attached	120 00
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Total	\$14,804 91
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Cost per cubic yard	38.03 cents
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Lowest bid received	44½ cents
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A statement of money expended is attached hereto, and you will note that the appropriation of \$17,000.00 has been fully expended.

A statement of all disbursements has been filed with the State Auditor.

Respectfully submitted,

ROBERT ISHAM RANDOLPH,

Secretary.

INVENTORY OF TOOLS TURNED OVER TO CITY OF SHAWNEETOWN.

- 10 drag scrapers.
- 1 6-horse plow.
- 1 4-horse plow.
- 51 No. 2 shovels (good.)
- 6 No. 2 shovels (cracked.)
- 4 spades.
- 3 grubbing hoes.
- 1 axe.
- 2 monkey wrenches.
- 3 water buckets and dippers.
- 2 6 ft. tool boxes with locks.
- 1 12 ft. x 14 ft. wall tent.
- Lumber for two loading traps.

DISBURSEMENTS SHAWNEETOWN LEVEE APPROPRIATION.

1907			
July	11	Isham Randolph, money advanced.....	\$ 475 12
Sept.	23	Evansville Courier, advertising.....	29 75
		Engineering Contracting, advertising.....	42 00
		Globe Printing Co., advertising.....	45 00
Nov.	2	Christian & Carver, tool boxes.....	6 00
	4	A. M. L. McBane, deed to property.....	100 00
	4	Mrs. J. M. Morris, deed to property.....	50 00
	4	Robinson Bros., merchandise.....	23 50
	4	A. K. Lowe's Sons, merchandise.....	16 40
	4	Lowe & Hubbard, merchandise.....	16 30
	4	Geo. Wiederholt, merchandise.....	50 50
	4	Chas. Carroll, merchandise.....	4 00
	4	Chas. Carroll, merchandise.....	2 00
	4	J. W. Quick, blacksmithing.....	11 85
	4	Bruns & Bowersock, lumber.....	40 18
	4	V. McMurchy, materials.....	2 65
	6	October payrolls.....	3,215 46
	7	Lou Mean, one heavy plow.....	10 00
	7	Tom Guest, rent of plows.....	1 00
	7	John Green, rent of plows.....	50
	20	United States Express Co., express.....	60
	22	Dr. Froelich.....	1 00
	24	November 15th payroll.....	2,279 67
	24	John Sporks. pump.....	4 00
Dec.	22	November 30th payroll.....	1,278 65
	31	John Sporks, balance on pump.....	2 00
	31	Lowe & Hubbard, merchandise.....	3 00
	31	Robinson Bros. merchandise.....	1 66
	31	A. K. Lowe & Sons, merchandise.....	22 90
	31	Chas. Carroll, merchandise.....	65
	31	A. T. Spivey, printing.....	6 50
	31	J. W. Quick, blacksmithing.....	12 10
	31	Bruns & Bowersock, lumber.....	29 49
	31	December 15th payroll.....	1,777 49
	31	December 31st payroll.....	144 56
1908			
Jan.	27	T. W. Clayton, salary November, December and January.....	314 50
		T. W. Clayton, expense account.....	12 50
	30	John Peeples, wages engineer assistant.....	54 00
	30	Chas. Colvard, wages engineer assistant.....	15 00
	30	Wm. F. Carney, wages engineer assistant.....	4 00
June	25	Payroll to June 15.....	286 15
July	2	Payroll to June 30.....	851 25
		Lowe & Hubbard, tools.....	4 15
		Porter Davis, shelter tent.....	10 00
	17	Payroll to July 15.....	976 51
Aug.	4	Payroll to July 31.....	1,715 33
		T. W. Clayton, salary and expenses June and July.....	316 47
		Marshall Wiseward, deed to land.....	300 00
	18	Isham Randolph, instruments.....	30 00
	18	Payroll to August 15.....	1,670 59
		Shawneetown News Gleaner.....	2 15
		Gallatin Democrat.....	2 40
		Robinson Bros.....	15 36
		Ham & Ham.....	6 50
	22	Express.....	3 40
	25	Payroll, final.....	533 35
		T. W. Clayton, August salary and expenses.....	165 60
		Stamps.....	2 51
			<hr/>
			\$17,000 00

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